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# IMPACT OF GOVERNMENT POLICIES

# UPON ENERGY EFFICIENCY IN TRANSPORTATION

Prepared For: Transport Canada
Energy Planning Directorate

Prepared By: F. P. Nix, R. K. House & Associates Ltd.,
Mississauga, Ontario

A. M. Clayton, Clayton, Sparks & Associates Ltd.
Winnipeg, Manitoba

D. Tanguay-Renaud, Montreal, Quebec

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## CONTENTS


| | | Page |
|---|---|---|
| Executive Summary | | i |
| Chapter 1 | Introduction | 1 |
| | 1.1 Objectives of the Study | 1 |
| | 1.2 Background: The Importance of Transportation Energy Issues | 3 |
| | 1.3 Conceptual Framework | 5 |
| | 1.4 Energy Efficiency Defined | 10 |
| | 1.5 Government Policy Defined | 12 |
| | 1.6 Study Methodology | 16 |
| | 1.7 Scope of Study | 18 |
| Chapter 2 | Transportation and Energy | 25 |
| | 2.1 Purpose of Chapter | 25 |
| | 2.2 Consumption Considerations | 26 |
| | 2.3 Supply Considerations | 30 |
| | 2.4 Technical Considerations | 32 |
| | 2.5 Cost Considerations | 39 |
| | 2.6 Transportation Demand Considerations | 41 |
| | 2.7 Energy Demand Considerations | 43 |
| | 2.8 Summary | 45 |
| Chapter 3 | Classification of Government Policies | 51 |
| | 3.1 Purpose of Chapter | 51 |
| | 3.2 Policy Perspectives | 51 |
| | 3.2.1 Sources | 51 |
| | 3.2.2 Mechanisms | 53 |
| | 3.2.3 Intentions | 54 |
| | 3.2.4 Timeframe | 54 |
| | 3.2.5 Interdependence | 55 |
| | 3.3 A Classification Scheme | 56 |
| Chapter 4 | Policies Affecting Prices | 59 |
| | 4.1 Purpose of Chapter | 59 |
| | 4.2 The General Effect of Prices | 60 |
| | 4.2.1 Energy (Fuel) Prices | 61 |
| | 4.2.2 Vehicle Prices | 65 |
| | 4.2.3 Infrastructure Prices | 66 |
| | 4.2.4 Service Prices | 67 |
| | 4.3 Policies Affecting Fuel Prices | 68 |
| | 4.4 Policies Affecting Vehicle Prices | 76 |
| | 4.5 Policies Affecting Infrastructure Prices | 89 |
| | 4.6 Policies Affecting Service Prices | 98 |
| | 4.7 Summary | 104 |

| | | Page |
|---|---|---|
| Chapter 5 | Infrastructure Policies | 111 |
| | 5.1 Purpose of Chapter | 111 |
| | 5.2 Policies Constraining Vehicle Size and Weight. | 113 |
| | 5.3 Policies Affecting Routing Efficiency. | 115 |
| | 5.4 Policies Affecting Vehicle Speed and Performance Requirements. | 117 |
| | 5.5 Policies Affecting Flow Quality. | 119 |
| | 5.6 Summary. | 121 |
| Chapter 6 | Vehicle Policies. | 123 |
| | 6.1 Purpose of Chapter | 123 |
| | 6.2 Types of Vehicles. | 123 |
| | 6.3 Policies Affecting Maximum Vehicle Size and Weight | 129 |
| | 6.4 Policies Affecting Minimum Vehicle Performance Capabilities. | 132 |
| | 6.5 Policies Affecting Fuel Type and Quality | 133 |
| | 6.6 Policies Affecting Fuel Economy. | 135 |
| | 6.7 Policies Affecting Vehicle Safety. | 137 |
| | 6.8 Policies Affecting Noise and Emissions | 139 |
| | 6.9 Policies Affecting Vehicle Maintenance | 141 |
| | 6.10 Policies Affecting Research and Development. | 142 |
| | 6.11 Summary. | 144 |
| Chapter 7 | Operating Policies. | 153 |
| | 7.1 Purpose of Chapter | 153 |
| | 7.2 Transportation System Operations | 153 |
| | 7.3 Policies Affecting Routing | 155 |
| | 7.4 Policies Affecting Speed | 158 |
| | 7.5 Policies Affecting Flow Quality. | 161 |
| | 7.5.1 Road Vehicles. | 162 |
| | 7.5.2 Aircraft | 166 |
| | 7.5.3 Marine and Rail. | 169 |
| | 7.6 Policies Affecting Operator Proficiency. | 170 |
| | 7.7 Policies Affecting Loads | 174 |
| | 7.8 Policies Affecting Service | 178 |
| | 7.9 Summary. | 188 |
| Chapter 8 | Summary and Conclusions | 195 |
| | 8.1 The Approach to Evaluation | 195 |
| | 8.2 Policy Areas-Transportation System Components. | 196 |
| | 8.3 Policies With No Impact | 199 |
| | 8.4 Policies With Little Impact. | 209 |
| | 8.5 Policies With Some Impact. | 215 |
| | 8.6 Policies With The Greatest Impact. | 223 |
| | 8.7 Conclusions. | 234 |

Page

Bibliography. . . . . 243

Appendix A: Government, Industry Contacts . . . . . 249

Appendix B: Technical Factors And Energy Efficiency . . . . . 251
B.1 Resistance. . . . . 251
B.2 Mechanical Efficiency . . . . . 255
B.3 Payload to Gross Weight Ratio . . . . . 258

## LIST OF TABLES & FIGURES


| | | Page |
|---|---|---|
| Figure 1.1: | Conceptual Framework: Basic Relations . . . . . | 6 |
| Figure 1.2: | Conceptual Framework: Scope of Study. . . . . | 19 |
| Table 1.1: | Transportation System (1980): Scope of Study. . . . . | 23 |
| Table 2.1: | Total Transportation Fuel Consumption: 1980 . . . . . | 27 |
| Figure 2.1: | Transportation Systems: Technical Factors Affecting Energy Efficiency . . . . . | 35 |
| Table 2.2: | Fuel Costs As Percentage of Total Operating Costs. . . . | 40 |
| Table 3.1: | Sources of Policy. . . . . | 52 |
| Table 4.1: | Forecast Fuel Prices in Cents per Litre:1982 . . . . . | 72 |
| Table 4.2: | Forecast Fuel Price Increase: 1982-1990. . . . . | 72 |
| Table 4.3: | Pump Prices (Regular, Leaded Gasoline): March 1983 . . . | 75 |
| Table 4.4: | Policies Affecting Vehicle (& Related Equipment) Prices. . . . . | 77 |
| Table 8.1: | Policy Areas - Transportation System Components. . . . . | 198 |
| Table 8.2: | Policy Areas With No Impact. . . . . | 200 |
| Table 8.3: | Policy Areas With Little Impact. . . . . | 210 |
| Table 8.4 | Policy Areas With Some Impact. . . . . | 216 |
| Table 8.5 | Assessment of Policies: Summary . . . . . | 235 |

(TP 4533 E)

# LES RÉPERCUSSIONS DES POLITIQUES GOUVERNEMENTALES SUR L'EFFICACITÉ DES TRANSPORTS DU POINT DE VUE ÉNERGÉTIQUE

Rédigé à l'intention de: Transports Canada
Direction de la Planification de l'énergie

Rédigé par: F.P. Nix, R.K. House & Associates Ltd., Mississauga (Ontario)

A.M. Clayton, Clayton, Sparks & Associates Ltd., Winnipeg (Manitoba)

D. Tanguay-Renaud, Montréal (Québec)

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## Résumé

La présente étude a été entreprise afin de déterminer dans quelle mesure les politiques gouvernementales existantes ont une incidence sur l'efficacité des transports du point de vue énergétique.

On a conceptualisé les activités relatives à la recherche, ainsi qu'une vaste gamme de renseignements obtenus du secteur industriel et du gouvernement, ainsi que des renseignements provenant de la documentation, afin de mener à bien la présente étude. On s'est également attardé à la définition des concepts-clés et à la relation qui existe entre eux. En somme, le point de vue conceptuel adopté par la présente étude, les définitions qui y sont élaborées et la prise en considération de certains rapports qui existent entre les concepts en présence sont venus déterminer la portée de l'étude et le but du travail accompli:

- la politique gouvernementale: englobe tout ce qu'accomplissent les divers paliers de gouvernement, que ce soit en matière de législation, de réglementation, d'arrêtés municipaux, de programmes, de normes ou tout simplement de mesures administratives. Notons toutefois que les activités, c'est-à-dire les décisions prises quotidiennement par les entreprises appartenant au gouvernement ou les sociétés d'État, ou encore les deux, ne sont pas comprises dans la présente définition de la politique gouvernementale;

- les politiques actuelles et les politiques que l'on pourrait vraisemblablement modifier: la présente étude ne s'est penchée que sur les politiques gouvernementales actuelles, c'est-à-dire en général le passé récent et l'avenir éventuellement proche, et elle s'est limitée aux politiques que l'on pourrait vraisemblablement modifier. Notons que le terme 'vraisemblablement' comporte la notion de dépenses gouvernementales (on a exclu par exemple les développements coûteux de l'infrastructure des transports, ainsi que les modifications que l'on y apporte) et l'aspect pratique des politiques (par exemple, on ne considère pas en général, l'assouplissement des normes relatives à la sécurité comme une modification qui pourrait être apportée à la politique);

- la classification des politiques: en raison du grand nombre d'activités effectuées par le gouvernement, on a classé en quatre groupes distincts les politiques gouvernementales: d'abord, les politiques qui ont une incidence sur les coûts du transport, soit le prix et le coût des facteurs de production et le prix des services; ensuite, les politiques qui ont des répercussions sur l'infrastructure des transports, soit par exemple les routes, les aéroports et ainsi de suite; ensuite, les politiques relatives aux véhicules; et, finalement, les politiques ayant des répercussions sur les procédures d'exploitation des services de transports. On a également établi un grand nombre de groupes secondaires, qui ont été traités essentiellement comme des domaines autonomes visés par la politique;

- le réseau des transports: la présente étude se penche sur six des volets les plus importants du réseau des transports: les voitures, les camions, le transport urbain et les autocars, les voies aériennes, maritimes et ferrées. La présente étude se limite de plus aux répercussions des politiques gouvernementales sur les principaux éléments ayant des répercussions sur la façon dont les six volets du réseau de transport assurent la prestation de services de transport. Notons que l'on n'a pas considéré les politiques gouvernementales rattachées à la demande en matière de transports;

- l'efficacité des transports du point de vue énergétique: ce concept est très difficile à cerner. Dans la présente étude, 'l'énergie' se définit comme l'énergie secondaire directe, destinée à la propulsion des véhicules. On peut également l'appeler 'carburant', bien que ce terme ne soit pas toujours des plus justes. On y définit également le terme 'efficacité', qui signifie l'efficacité technique du rendement ou le rapport qui existe entre les extrants physiques (les services de transport) et les intrants physiques (l'énergie, ou encore le carburant). Il est évident que l'efficacité des transports du point de vue énergétique, c'est le rapport qui existe entre les services de transports assurés et l'énergie utilisée. Par contre, puisque presque toutes les mesures quantifiables du numérateur de ce rapport telles, par exemple, les passagers ou les tonnes au kilomètre, ne comprennent aucune mesure du service ou de la qualité, il est souvent trompeur de comparer ce rapport d'un service de transport à un autre. La présente étude ne compare donc pas les divers volets du réseau des transports;

- <u>les répercussions sur l'efficacité des transports du point de vue énergétique</u>: on doit considérer les répercussions des politiques gouvernementales sur l'efficacité des transports du point de vue énergétique sous l'aspect des facteurs techniques fondamentaux qui viennent déterminer l'efficacité sur le plan énergétique. Pour ce motif, la présente étude comprend une étude de questions telles la résistance (la résistance au roulement, le tirage aérodynamique, et ainsi de suite), l'efficacité mécanique (c'est-à-dire l'efficacité des systèmes de propulsion) et le rapport qui existe entre la charge utile et le poids brut du véhicule. Notons que les politiques gouvernementales ont une incidence sur l'efficacité des transports du point de vue énergétique des façons suivantes: i) l'accroissement ou la diminution de la résistance totale à surmonter; ii) l'accroissement ou la diminution de l'efficacité mécanique des systèmes de propulsion; iii) l'accroissement ou la diminution du rapport qui existe entre la charge utile et le poids brut du véhicule;

- <u>d'autres considérations</u>: la présente étude avance bon nombre d'autres considérations qui viennent faciliter l'évaluation des politiques ou qui, si elles ne servent pas directement à l'évaluation des procédures, touchent en quelque sorte les résultats obtenus. "Les considérations relatives à l'offre": même si la présente étude ne traite pas formellement la question des politiques gouvernementales touchant l'offre en matière d'énergie, ces questions doivent être prises en considération par certaines politiques. "Les considérations relatives aux coûts": on s'attarde en quelque sorte au coût relatif de l'énergie en ce qui a trait aux divers volets du réseau des transports et tout particulièrement au fait que le coût des carburants représente une proportion importante des coûts totaux d'exploitation, ce qui laisse supposer que le secteur des transports a intérêt à mettre au point de nouvelles techniques et pratiques plus efficaces, ou les deux. "Les considérations relatives à la demande": en dépit du fait que l'on ne traite pas formellement la question des politiques touchant la demande en matière de transports, on ne peut l'ignorer si l'on apprécie les répercussions probables de certaines politiques. "Les considérations relatives à la consommation": l'importance relative de la consommation totale d'énergie de chacun des volets du réseau des transports se révèle un des facteurs influant le plus sur l'appréciation des politiques. Par exemple, on estime que les voitures et les camions légers consomment 65 pour cent de l'énergie et que les services de voies ferrées destinées aux passagers n'en consomment que 0,4 pour cent.

Afin d'être en mesure de déterminer les répercussions des politiques gouvernementales sur l'efficacité des transports du point de vue énergétique, on s'est servi, aux fins de la présente étude, des sources de données existantes sur la consommation de l'énergie, les activités relatives au transport, et ainsi de suite, et d'une vaste gamme de documents portant sur le mécanisme qui sous-tend diverses politiques et l'importance de ces dernières. Précisons que la grande partie du travail accompli aux fins de l'étude consistait à s'entretenir avec les représentants du gouvernement et du secteur industriel afin de recueillir leur avis sur l'importance des diverses questions visées par les politiques.

Cette méthode de travail a soulevé un grand nombre de difficultés. En effet, une grande partie des sources de données existantes sont médiocres, à tel point que la simple détermination de la consommation d'énergie de chacun des volets du réseau des transports pose un problème. De plus, la documentation qui existe sur les répercussions des politiques ne suffit pas à nos besoins et se révèle souvent contradictoire. Finalement, la kyrielle d'opinions émises par les représentants du gouvernement et du secteur industriel peuvent servir à étayer plusieurs avis, souvent divergents, sur l'importance de diverses politiques. Les résultats de la présente étude ne peuvent donc pas être considérés comme définitifs ou quantifiables. Dans la plupart des cas, on peut considérer les résultats de la présente étude à plus juste titre comme des jugements convaincants, et il reviendra aux lecteurs d'en apprécier la justesse.

Dans le dernier chapitre du présent rapport, on divise les politiques du gouvernement selon quatre répercussions différentes: d'abord, aucune répercussion, ce qui signifie que les politiques n'ont aucune répercussion sur l'efficacité sur le plan énergétique, ou encore des répercussions négligeables (si elles pouvaient être mesurées) ou qu'on ne dispose d'aucune preuve justifiant l'existence des répercussions importantes, ensuite, peu de répercussions, ce qui signifie des répercussions éventuellement positives ou négatives sur l'efficacité sur le plan énergétique, soit moins de un pour cent de la consommation totale de carburant au chapitre des transports; des répercussions, ce qui signifie des répercussions éventuellement positives ou négatives soit moins de cinq pour cent de la consommation totale de carburant au chapitre des transports; et, finalement, d'importantes répercussions, ce qui signifie des répercussions éventuelles soit plus de cinq pour cent de la consommation totale de carburant.

Précisons que seules quatre domaines visés par la politique relève de la dernière division, soit "d'importantes répercussions". De plus, on considère que trois de ces quatre domaines ont au plus des répercussions éventuelles, compte tenu de certaines modifications apportées aux politiques, plutôt que des répercussions réelles déjà documentées et appréciées.

1. Les politiques fédérales et provinciales régissant le prix du carburant: sont de loin les plus importantes politiques pour ce qui est de l'efficacité des transports du point de vue énergétique et ce sont sans doute les seules que l'on peut considérer comme ayant des répercussions réelles et mesurables, selon les conclusions préliminaires tirées par certains auteurs.

2. Les politiques fédérales et provinciales relatives aux prix des véhicules et du matériel connexe: une myriade de mesures, mises en oeuvre surtout par le gouvernement fédéral, rendent assez intéressant un investissement dans les nouveaux véhicules de la part des exploitants du transport commercial, ce qui a une incidence positive sur l'efficacité sur le plan énergétique, comme nous l'avons d'ailleurs déjà expliqué. Par contre, certains éléments viennent contrebalancer cet aspect positif: d'abord, très peu de ces politiques ont été conçues expressément pour influer sur l'efficacité sur le plan énergétique, ensuite, ces mesures ne sont pas aussi avantageuses que celles que l'on retrouve au sein des autres secteurs de l'économie, même si elles stimulent l'achat de véhicules neufs et plus efficaces, et finalement, ces mesures ne s'appliquent en général pas aux petits véhicules, volet à caractère non commercial du réseau des transports (voitures et camions légers). C'est surtout en raison de ces éléments négatifs que l'on estime que ce domaine a des répercussions importantes sur les politiques. Précisons qu'il est possible que les répercussions portent sur plus de cinq pour cent de la consommation de carburant.

3. Les politiques fédérales et provinciales qui influent sur l'entretien des véhicules: à l'heure actuelle, les règlements ou les programmes touchant à l'entretien des véhicules ne s'intéressent pas à l'efficacité sur le plan énergétique, bien qu'il existe certaines politiques de promotion à cet égard. De l'aveu de tous, on ne sait pas s'il est possible que ces règlements et programmes s'intéressent à cette question, et, si la chose était de fait possible, dans quelle mesure ces derniers traiteraient la question d'une façon efficace. Notons qu'au moins un gouvernement provincial a examiné la question et a mis en doute l'efficacité de telles politiques. Toutefois, si l'on prend en considération l'élément de voiture et camion léger du réseau des transports, il est fort possible que ce domaine, que l'on peut qualifier de neutre, doive être considéré comme ayant des répercussions importantes sur les politiques.

4. Les politiques fédérales et provinciales qui ont une incidence sur les compétences des exploitants: les compétences des conducteurs de voitures et de camions légers peuvent être améliorées de beaucoup, et même de légères améliorations auraient des répercussions sensibles sur l'efficacité du réseau des transports du point de vue énergétique. Encore

une fois, ces deux volets représentent ensemble 65 pour cent de la consommation totale d'énergie. Ce domaine ressemble au domaine précédent sur les points suivants: d'abord les politiques actuelles qui ont une incidence sur les compétences des conducteurs ne s'intéressent en général pas à l'efficacité sur le plan énergétique, ensuite, on y retrouve par contre quelques exceptions ainsi que des politiques à caractère promotionnel. Finalement, on n'a toujours pas prouvé de façon convaincante que les politiques gouvernementales pourraient permettre d'améliorer les compétences des conducteurs.

Notons que trois de ces domaines touchent surtout ou même exclusivement aux voitures et aux camions légers. Étant donné leur consommation en carburant, un tel résultat était presque inévitable. Précisons également qu'une grande partie des questions revenant le plus souvent dans les études sur l'efficacité des transports du point de vue énergétique, ne font pas partie des éléments ayant les répercussions les plus importantes sur les politiques. Songeons par exemple à l'exploitation du transport urbain, aux services de voies ferrées destinés aux passagers, aux lignes directrices élaborées par le gouvernement fédéral relativement à l'économie de carburant et dstinées aux fabricants de voitures, les règlements portant sur les dimensions et le poids des camions, la réglementation sur le plan économique des opérations de location, la gestion des réseaux de circulation urbaine, et ainsi de suite. Ceci résulte en partie des considérations rattachées à la consommation totale de carburant, mais non totalement. Bien que l'on n'ait aucune preuve précise à cet effet, on peut tout de même justifier le fait que certains mythes existent à l'égard de l'importance des questions qui reviennent le plus souvent.

En guise de conclusion, et afin de résumer les résultats de la présente étude, on ignore toujours la mesure dans laquelle les politiques gouvernementales ont une incidence sur l'efficacité des transports du point de vue énergétique. Si l'on voit tout en noir, le nombre, ou l'importance, des politiques conçues expressément en vue de l'efficacité sur le plan énergétique semble peu élevé. On a souligné maintes et maintes fois le fait que cette opinion est relative et que des questions telles la préservation, qui pourrait englober l'efficacité, ou la substitution doivent se distinguer de l'efficacité. Si l'on voit tout en rose, il n'existe aucune preuve convaincante qui laisse supposer que les politiques gouvernementales ont ralenti le processus par lequel le réseau des transports a gagné en efficacité du point de vue énergétique, puisque les améliorations apportées au cours des dix dernières années sont impressionnantes. Il est donc évident que c'est dans le domaine des voitures et des camions légers, les plus grands utilisateurs de carburant destiné au transport, que les politiques gouvernementales pourraient avoir une plus grande influence sur l'efficacité, et c'est d'ailleurs le cas. En effet, les voitures et les camions légers consomment tellement de carburant et, par conséquent, il existe tellement d'occasions à saisir en vue d'accroître leur efficacité à ce niveau, que la plupart des autres considérations, telles les autres domaines et les autres éléments du réseau des transports, nous semblent, par compairaison, sans grande importance.

## Executive Summary

This study was commissioned to identify the extent to which existing government policies have an impact on transportation energy efficiency.

To conduct this study, research activities and a wide variety of information obtained from industry, government and literature sources have been organized into a conceptual framework. Further, considerable attention has been given to the definition of critical concepts and to a consideration of certain other key relationships. Briefly, the conceptual framework, the definitions, and the consideration of certain relationships determined the scope of the study and the focus of the work:

- government policy: is defined to be all "things" the three levels of government do, whether these "things" are legislation, regulation, bylaws, programs, standards, or simply administrative actions. However, the activities (or day-to-day decisions) of government-owned enterprises and/or crown corporations are not included in this definition of government policy.

- "current" policies and policies which could be "feasibly" changed: the study only examined "current" government policies, where "current" was defined non-rigorously to mean the recent past and the (potential) recent future; and, the study was limited to a consideration of only those policies which could "feasibly" be changed, where "feasibility" includes the notion of government expenditure (for example, costly additions to or modifications to transportation infrastructure were excluded) and the notion of practicality (for example, relaxation of safety standards were not generally considered a feasible policy change).

- government policies classified: owing to the immense number of things governments do, all government policies were grouped into four major areas: policies affecting transportation prices (both factor input

prices or costs, and service prices); policies affecting transportation infrastructure (roads, airports, etc.); policies affecting transportation vehicles; and, policies affecting transportation operating procedures. Within each of these four main categories, a number of sub-categories were developed and treated as more-or-less homogeneous policy areas.

- transportation system: the study considers six main components of the transportation system: automobiles, trucking, urban transit and intercity busing, air, marine, and rail. Further, the study limits its attention to the effect of government policies on the primary elements affecting the way these six components supply transportation services. Government policies specifically affecting the demand for transportation are not considered.

- transportation energy efficiency: there is no precise way to define "transportation energy efficiency". In this study, the "energy" considered is the "direct secondary energy" used for vehicle propulsion: a good, although not always accurate synonym is "fuel". "Efficiency" is defined as the technical efficiency of production, or, the ratio of physical outputs (transportation service) to physical inputs (energy, or fuel). "Transportation energy efficiency" is obviously the ratio of transportation output to energy input; but, because almost all quantifiable measures of the numerator of this ratio (for example, "passenger-kilometre" or "tonne-kilometre")do not incorporate any measure of service (or "quality"), comparisons of this ratio between one transportation service and another are very often misleading. For this reason, this study does not make efficiency comparisons between the various components of the transportation system.

- impact on transportation energy efficiency: the effect of government policies on transportation energy efficiency has to be understood in terms of the basic technical factors which determine energy efficiency. For this reason, the study included a review of such subjects as resistance (rolling resistance, aerodynamic drag, etc.), mechanical efficiency (that is, the efficiency of propulsion

systems), and the ratio of payload to gross vehicle weight. Government policies affect transportation energy efficiency by i) increasing or decreasing the total resistance to be overcome, ii) increasing or decreasing the mechanical efficiency of propulsion systems, or iii) increasing or decreasing the payload to gross weight ratio.

- other considerations: the study introduces a number of other considerations that either assist in the evaluation of policies or, if not used directly in the evaluating procedures, have a bearing on some of the findings. "Supply-side considerations" - although the study does not explicitly treat the subject of government policies affecting the supply of energy, these issues have to be considered in some policy areas. "Cost considerations" - some attention is given to the relative cost of energy to the various components of the transportation system; in particular, the fact that fuel costs comprise a significant proportion of total running costs suggests that the transport sector has a strong incentive to seek more efficient technologies and/or practices. "Demand considerations" - although policies affecting the demand for transportation are not explicitly considered, the subject of transportation demand cannot be totally ignored in evaluating the likely impact of some policies. "Consumption considerations" - one of the primary factors influencing the evaluation of policies is the relative importance of each transportation component's share of total transportation energy consumption: in particular, automobiles and light trucks account for an estimated 65% of total energy consumption; rail passenger services, on the other hand, account for 0.4%.

To determine the impact of government policies on transportation energy efficiency, the study relied on existing data sources (on energy consumption, transportation activities, etc.) and a wide variety of literature sources (on the mechanism of or the importance of various policies). In addition, much of the actual work of the study consisted of interviewing government and industry sources for their opinions on the importance of different policy areas.

These procedures resulted in a number of difficulties for the study: many of the existing data sources are poor (for example, simply determining the total energy consumption of each component of the transportation system is a problem); the existing literature on the impact of policies is scanty

and often conflicting; and, the multitude of opinions held by government and industry sources can be used to support any number of views - often very different views - on the importance of various policies. For these reasons, the findings of the study cannot be presented as "hard" or quantifiable magnitudes. In most cases, the study findings are more accurately characterized as reasonable judgements, the merits of which reasonable readers may well choose to debate.

In the final Chapter of this report, government policies are classified in terms of four impacts: i) "no impact", which is defined as absolutely no impact on energy efficiency, or as impacts which are either insignificant (if they could be accurately measured) or for which there is no acceptable evidence to suggest any significant impact; ii) "little impact", which is defined as a possible positive or negative impact on energy efficiency amounting to less than 1% of total transportation fuel consumption; iii) "some impact", which is defined as a possible positive or negative impact of less than 5% of total transportation fuel consumption; and iv) "greatest impact", which is defined as a possible impact of over 5% of total transportation fuel consumption.

Only four policy areas qualify for this fourth category - the "greatest" impact. Further, three of these four areas are best considered as potential impacts, given some policy change, rather than actual impacts which have been documented and measured.

1. Federal and provincial policies governing fuel prices: This is by far the most important policy affecting transportation energy efficiency; and, it is probably the only one that can be considered as having an actual, and, according to the preliminary evidence of some authors, a measurable impact.

2. Federal and provincial policies affecting vehicle (and related equipment) prices: there is a whole series of measures, primarily at the federal level, that make it relatively attractive for commercial transport operators to invest in new vehicles. This, as explained in the report, generally has a positive impact on energy efficiency. Offsetting this "plus" is the fact that i) very few of these policies were specifically designed to have an impact on energy efficiency; ii) these measures, although offering

incentives for the purchase of new, more efficient vehicles, are not as attractive as measures available to other sectors of the economy; and iii) these measures are generally not extended to the small vehicle, non-commercial components of the transportation system (automobiles and light trucks). It is primarily because of these "negative" factors that this policy area has been included in the "greatest impact" category. That is, there is a "potential" here for having an impact which could affect more than 5% of transportation fuel consumption.

3. Federal and provincial policies affecting vehicle maintenance: currently, there is little "energy-efficiency" content to government regulations or programs concerned with vehicle maintenance. (There are, of course, "promotional" policies in this area.) Admittedly, it is not known if there could be - or, if there could, how effective such an "energy-efficient" content would be. (At least one provincial government has looked at this issue and has also expressed some reservations as to how effective such policies would be.) Nevertheless, considering the automobile and light truck component of the transportation system, there is enough potential here that this policy area (which now could be described as "neutral") has to be included in the "greatest" impact category.

4. Federal and provincial policies affecting operator proficiency: there is an enormous potential for improving the level of skill of drivers of automobiles and light trucks. That is, even small improvements would have a very large effect on the energy efficiency of the transportation system (again, these two components account for 65% of total consumption). This policy area is similar to the previous: current policies which do affect driving skill are generally devoid of an "energy-efficient" content; there are some exceptions to this statement and there are some "promotional" policies; and, the possibility that government policies could actually be effective in improving driving skill is somewhat untested.

It will be noted that three of these policy areas are primarily (or solely) concerned with automobiles and light trucks. This, of course, was almost a guaranteed outcome of the study, given the fuel consumption of these components. It will also be noted that many of the "favorite" topics treated in studies on transportation energy efficiency have not made the

"greatest impact" list: urban transit operations, rail passenger services, the federal government's fuel economy guidelines for automobile manufacturers, truck size and weight regulations, economic regulation of for-hire operations, urban traffic system management, and so on. This is also partly because of total fuel consumption considerations - but not totally so. Although precise evidence is lacking, the evidence that is available suggests that there are some myths surrounding the importance of these "favorite" subjects.

Finally, to summarize the findings of this study, the precise extent to which government policies affect transportation energy efficiency is not known. In a negative sense, the number or importance of policies designed specifically to do something about energy efficiency appears to be small: repeated warnings are made that this is a relative statement, and that subjects such as "conservation" (which may include efficiency) or "substitution" have to be distinguished from "efficiency". In a positive sense, there is no strong evidence to suggest that government policies have retarded the rate at which the transportation system has become more energy efficient: the improvements over the last decade or so have been impressive. It is clear that the most important area where government policies could (and do) affect efficiency involves the largest users of transportation fuel - automobiles and light trucks. Indeed, these users account for so much fuel and the opportunities for increasing efficiency appear so large that most other considerations - other policy areas, other transportation components - pale by comparison.

# Chapter 1 Introduction

## 1.1 Objectives of the Study

This study was commissioned to identify the extent to which existing government policies have an impact on transportation energy efficiency in Canada. This is not an easy task. Anyone who has attempted to grapple with this issue quickly realizes that there are severe problems imposed by the quality of the existing data sources, the conflicting nature of the literature sources and the opinions held by various people in government and industry, and the wide assortment of meanings that can be given to such terms as "the transportation system", "government", "policy", and even "energy efficiency".

The purpose of this Chapter is to bring some order to the subject by developing a conceptual framework for dealing with the issue, and by defining some of the key concepts. This framework and the definition of concepts are the primary determinants of the scope of this study (Section 1.7). This is followed in Chapter 2 by a more detailed consideration of energy use by the transportation system and in Chapter 3 by a consideration of how government policies can be classified.

It has to be stressed that the issue of the impact of government policies on transportation energy efficiency cannot be understood without reference to this conceptual framework, the definitions, and the considerations introduced in Chapters 2 and 3. Indeed, to go further, one of the reasons for some current confusion on the subject of government policies and transportation energy efficiency is the lack of attention that has been given to these matters.

The purpose of this study is to clarify these issues and, having done this, to determine which government policies have "no" impact, "little" impact, "some" impact, and a "major" impact on transportation energy efficiency. From the outset, it is recognized that the attempt to develop a new way of looking at the issue, the struggle with incomplete and poor data sources, the coping with spotty and conflicting evidence, and the exercise of judgement required to develop the "no", "little", "some", and "greatest" categories, leaves the whole subject open to considerable debate. This is desirable; if nothing else, and if this study does not resolve all issues for all people, this study has the objective of channeling this debate along more constructive paths.

## 1.2 Background: The Importance of Transportation Energy Issues

Many reports on transportation energy issues begin by explaining why the subject is important. Because this has been well-documented, it is not necessary to repeat the explanation here. Rather, distilling from these other reports, there are four major points that bear repeating.

First, the transportation system itself is important. This importance is far larger than is indicated by its 5% to 6% share of gross domestic product: the figures 5% to 6% seriously underestimate the true size of transportation activities (most private transportation is excluded); and, whatever the true size, transportation is the critical link between most other economic and social activities.

Second, transportation is a major consumer of energy. Various studies (depending on data sources and methodology) suggest transport consumes over 25% of total energy consumption in Canada[1]; and, of more importance, transport consumes about one-half of petroleum-derived energy.[2]

Third, a major component of government's energy policy in Canada (the National Energy Program) is to hold transportation oil consumption constant at 1979 levels through to 1990. This is known as the "transportation energy cap".

Fourth, for a variety of reasons, many people do not believe that energy prices alone will ensure that the transportation system will modify its use of energy quickly enough to ensure the achievement of this transportation energy cap. If this is true, so the reasoning goes, government transportation planners and policy-makers have a role to play in inducing the transportation system to modify its energy-use policies.[3]

None of these issues - the importance of transportation, the importance of energy consumption by transport, the transportation energy cap, or the possibility that energy prices alone will not be sufficient to achieve this cap - are of direct concern to this study. However, they all have a bearing on the overall study objectives. In particular, since the achievement of higher levels of transportation energy efficiency is one method of ensuring the attainment of the transportation energy cap, it is important to understand how or where government policies affect energy efficiency.

## 1.3 Conceptual Framework

From the start of the study, it was recognized that the collection of a wide variety of material on policies from many different sources and the collection of "bits and pieces" of data on the transportation system - and energy use by the transportation system - had to be organized within some framework to make the study manageable. The conceptual framework adopted is shown on Figure 1.1.[4]

Transportation can be visualized as a set of three interrelated variables: (A) the TRANSPORTATION SYSTEM, which consists of operators, vehicles, infrastructure, prices paid by operators for all of those necessary "inputs" to the system, operating rules or methods, and many other elements; (B) the ACTIVITY SYSTEM, which is the totality of all social, economic, political, or other transactions giving rise to the demand for transportation; and (C) the FLOWS of people or goods. There are three relationships between these variables, as shown on Figure 1.1. Relationship [1] is the interaction of the transportation system (the supply) and the activity system (the demand) in determining the flow pattern; relationship [2] is the effect flow patterns have on the transportation system - for example, high levels of congestion may lead to more freeways being

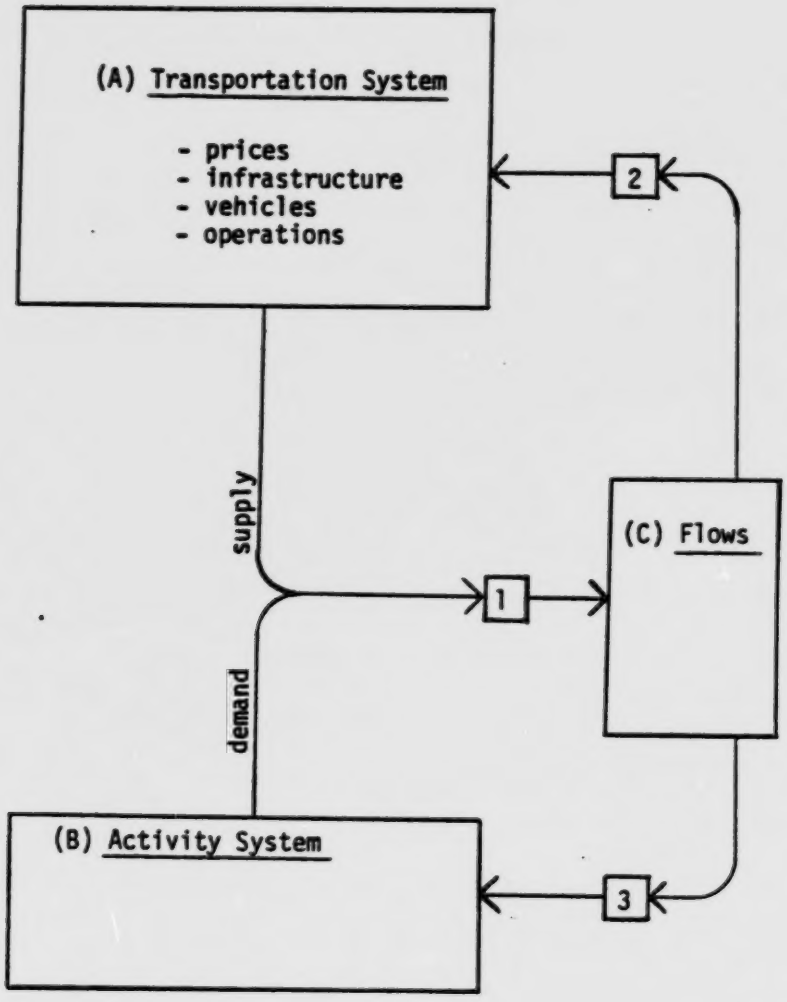



Figure 1.1: CONCEPTUAL FRAMEWORK: BASIC RELATIONS

built; and, relationship [3] is the effect the flow patterns have on the activity system - for example, high levels of congestion may cause people to live in some areas of a city in preference to other areas and thereby affect real estate prices or even land use.

The adoption of this framework helps to clarify one aspect of what is meant by the phrase "impact on the transportation system". Consider, for example, one type of policy which has received much attention in the literature as one means whereby governments could have a positive impact on transportation energy efficiency: reducing the number of stop signs in urban areas. If a study, such as this one, were to evaluate the effectiveness of such a policy, it could do so on at least four different levels:

i) the "technical" level: by considering only the elements within the transportation system, that is, the elements in (A) on Figure 1.1, the energy savings attributable to the elimination of a stop sign could be calculated. This could be done by considering the technology of a given vehicle, some of the characteristics of infrastructure, and the technical factors determining energy use - "mechanical efficiencies" of propulsion systems, "rolling resistance", and so on.

ii) transportation flows: for a given level of demand (that is, assume the activity system (B) is held constant), there is a certain flow of vehicles over the urban road network. This is relationship [1] on Figure 1.1. These flows can be counted, and various techniques - emptrical measures, models - can be used to calculate the effect on flows of removing stop signs. Furthermore, other techniques - fuel-measuring devices, the "technical" considerations discussed under the previous point - can be used to calculate the impact on energy use.

iii) the effect of flows on the activity system: in all likelihood, a change in the road infrastructure (such as the removal of stop signs) will affect flows (relationship [1]) in such a manner so as to cause some change in the activity system (relationship [3]). In the present case, assume the removal of stop signs reduces average travel time which in turn encourages more people to drive their own cars to work. The evaluation of the policy of removing stop signs would now have to consider the net effect on energy use of the "induced" demand for private automobile travel (presumably at the expense of transit ridership or ride-sharing).

iv) the effect of flows on the transportation system: finally, at a fourth level, a change in the infrastructure (removal of stop signs) will affect flows (relationship [1]) which, in turn, can cause changes within the transportation system (A). Although in the present case it stretches the imagination to think just what these changes might be, assume for the sake of illustrating the point that the removal of stop signs caused a reduction in average travel time and also caused an increase in accident rates. The evaluation of the energy impacts of this policy of removing stop signs might now have to consider the additional energy use associated with accidents, or (possibly) the additional energy use associated with heavier cars that some operators now purchased in an attempt to minimize the risk of injury.

The realism of this example is not important. Further, there are other considerations - such as "what is energy?", "what is efficiency?", "what is policy?", etc. - that will be dealt with in subsequent sections.

What is important here is, first, the realization that any study which attempts to evaluate the transportation energy impacts of policies has to choose one or more of these levels as a framework for dealing with a highly complex, dynamic, and interrelated series of systems. In this study, a deliberate choice has been made to concentrate on the technical relationships within the transportation system (A) and the energy use associated with transportation flows (relationship [1]). The activity system (B) and relationships [2] and [3] are either ignored or assumed constant.

The second important point is the realization that this attempt to concentrate on only some of the elements and some of the relationships depicted in Figure 1.1 is bound to be frustrated by the use of the available literature, data, and informed opinions on the subject. The reason for this is simply that there is no consistency among all these different sources in the particular frameworks chosen for addressing the issues.

## 1.4 Energy Efficiency Defined

The terms "energy" and "efficiency" can both be defined in several ways. In this study, energy is defined as only the "direct secondary energy" used by vehicles for propulsion: a good, although not always accurate synonym for energy in this study is "fuel". Other aspects of energy consumption by the transportation system are not considered: for example, the energy used to produce and distribute fuel to retail outlets, or the energy used to build and maintain infrastructure.

Efficiency is a measure of how well resources are used to produce something. Although the concept of efficiency is complex and although there are several ways of using the concept, in this study it is only the "technical efficiency of production" which is of concern. In the present case, efficiency is the ratio of "transportation output" to "energy input".

The denominator in this ratio is easily characterized and measured in non-controversial scientific terms - joules, foot-pounds, calories, BTUs, or, when dealing with one type of fuel, simple measures of volume such as litres or gallons. The numerator, on the other hand, is not easily characterized or measured. "Transportation

output" is a multi-dimensional concept, incorporating both "hard" - and easily measured aspects of flows, and "soft" - and not so easily measured aspects. Traditionally, most transportation energy studies employ only the "hard" aspects of transportation output, such as "passenger-kilometres" or "tonne-kilometres".

The failure to recognize the "soft" attributes of flows - such as "speed", "comfort", "safety", or more generally "service characteristics" - leads to a fundamental problem. In essence, comparisons of the energy efficiency of one type of flow with another are typically simplistic, and often of little use. For example, the statement that subways are more energy efficient than automobiles is simply incorrect. While it may be true that a subway can produce a given number of passenger-kilometres for less direct secondary energy than an automobile, it is misleading to characterize the quality of a passenger-kilometre of travel by subway as comparable to a passenger-kilometre of travel in an automobile.

For this reason, no attempt is made in this study to compare energy efficiencies among different

components of the transportation system. Although it is difficult to be totally rigorous about this, as a general rule this study does not examine policies which have any impact on diverting the demand for travel or the demand for freight movements from one type of transportation service to another.

## 1.5 Government Policy Defined

There is a problem in any study dealing with government activity in defining just what is meant by the term "government policy". The problem is compounded by the fact that one cannot simply go to a library reference shelf and find a compendium of such policies, nor can one ask governments to provide a convenient catalogue. Obviously, in view of the objectives of this study, there is a need to develop a definition of this concept.

There are a number of dilemmas in developing this definition. First, is "policy" to be defined as those very broad objectives of government that one sometimes hears in speeches by politicians, or is it to be defined much more narrowly as each and every action of all government departments and each and every regulation made pursuant to some act? If the broad concept is used, there would be some difficulty in trying to assess the impact of such things as "the policy to promote industry"

or "the policy to reduce unemployment". If the narrower concept is to be employed, the study runs the risk of bogging down in detail. The Economic Council of Canada has noted that at the federal level alone, there are 140 "regulatory" statutes which have given rise to 9,475 pages of statutory instruments - almost one-half of which apply to the transportation system. The provincial and municipal field is far more crowded.[5]

The second dilemma is knowing what is meant by "government": what level? which departments? which agencies? which crown corporations?

The third dilemma is attempting to decide what timeframe should be used. Is the "policy" which gave the CPR the southern route across the west and the other railways the northern routes still an issue? Given enough time, someone could undoubtedly show that this policy had an impact on energy use.

A fourth dilemma is deciding whether "policy" means just those things governments do or whether it also includes "non-actions". For example, various provinces have almost identical legislation in place empowering semi-autonomous boards to regulate segments of the trucking industry;

nevertheless, in some provinces there is de facto regulation and in others there is not. Assuming regulation has an effect on energy efficiency, is it the de jure actions of government that are of interest here or is it the de facto?

A fifth dilemma is knowing whether the policies to be assessed here include everything governments do (or don't do, as the case may be), or only those things which could be feasibly changed. For example, governments could adopt the "policy" of extending the St. Lawrence Seaway/Welland Canal/Great Lakes waterway clear across the continent. Is the fact that they have not, a "policy" (or "non-action") which this study should attempt to assess?

Any resolution of these issues is, to some extent, arbitary. However, choices have to be made, and to clarify the scope of this study, the following approach will be taken in defining "government policies":

- "government policy", for this study, means all of those "things" the three levels of governments do in the narrowest sense of the word. However, to avoid the problem of bogging down in too much detail, similar types of policies are grouped together under broad headings.

- "government" means ministers, departments, agencies, or local government officials who make or administer legislation. It also includes the actions and/or decisions of these various ministers, departments, agencies, or local government officials. It does not include any actions or decisions of crown corporations or government-owned operating enterprises (for example, Air Canada, the St. Lawrence Seaway Authority, the National Harbours Board, provincially-owned commuter or ferry services, or locally-operated urban transit systems).

- the study is only concerned with current policies, where "current" means both the recent past and possible policies in the near future.

- in some instances, "policy" can include things governments are not actually doing ("non-action" can be a policy).

- the only policies of interest to this study are those which feasibly could be changed and those which do not involve major expenditures of public money. It will be noted that this statement avoids a precise definition of "feasible" or "major expenditure". This is deliberate: good judgement suggests that it is not "feasible" to abandon the government regulation which requires automobiles to have bumpers (the added weight of bumpers increases fuel consumption) and that a policy of building grade separations for every rail crossing, twinning runways at airports, or building a canal across the prairies involves a "major expenditure" of money (in all cases, these additions to transportation infrastructure would reduce the fuel consumption required for a given flow of people or goods).

With these qualifications and/or restrictions to the concept of "government policy", this study examines those policies

affecting the transportation system, as these policies affect transportation energy efficiency, with the focus being on relationship [1] in Figure 1.1 and all other systems and/or relationships assumed constant.

## 1.6 Study Methodology

There are five main points to note about the methodology employed in this study. First, this study made no attempt to generate data. All figures on energy consumption and all information on changes in energy efficiency were taken from existing sources: where conflicting numbers were found, the study attempted to steer a middle course without getting embroiled in the debate on the accuracy of various sources. Second, the starting point for assessing the impact of government policies on transportation energy efficiency has been to examine the basic technical factors which determine energy efficiency and, from there, the study has attempted to work back to find which government policies were at work affecting which technical factors. Third, there has been a heavy reliance on literature sources for information. Although these sources are listed in the Bibliography, an attempt was made to keep the number of citations in the notes to each Chapter to a minimum. A complete discussion of these literature sources

was the subject of a series of working papers completed during the conduct of the study. Fourth, to gain some insights on policies and the perceived importance of policies, the work undertaken for this study involved extensive interviews with government and industry officials; a list of these people is contained in Appendix A to this report.

The fifth methodological point concerns the decisions made with respect to the subject matters included in this report. As the object of this study was the determination of the impact of government policies, including those cases where there was no impact, it is evident that the potential scope of this study could have been very large. However, based on the analysis of the technical factors affecting energy efficiency, a large body of government policy areas could be eliminated immediately. For example, there is no need in this report to consider government policies on broadcasting. The remaining policies - that is, those where the analysis of technical factors suggested there could be an impact - have been grouped into policy areas. The process of classifying policies is described in Chapter 3.

Even with this grouping of policies into areas where there is some potential for affecting energy efficiency,

it was found that there were some groups of policies that had little or no impact on energy efficiency. These "no" impact policies must nevertheless still be dealt with in this report - that is, given the overall study objectives.

## 1.7 Scope of Study

Having developed a conceptual framework and defined both transportation energy efficiency and government policy, Figure 1.2 shows the scope of the study. The primary focus is to assess the extent to which government policies affect the transportation system - in particular, the extent to which policies affect the technical factors which determine energy efficiency.

In total, the transportation system encompasses everything from the most visible components such as trains, planes, trucks, cars, buses, etc. to the less visible - or more ignored components such as conveyer systems, sewage systems, horse and buggy operations, bicycles, etc. The transportation system also includes what may be called the "new technology" systems such as lighter-than-air vehicles, slurry pipelines, submarines, hovercraft, etc.; what may be called the primarily "recreational" component such as private airplanes, pleasure

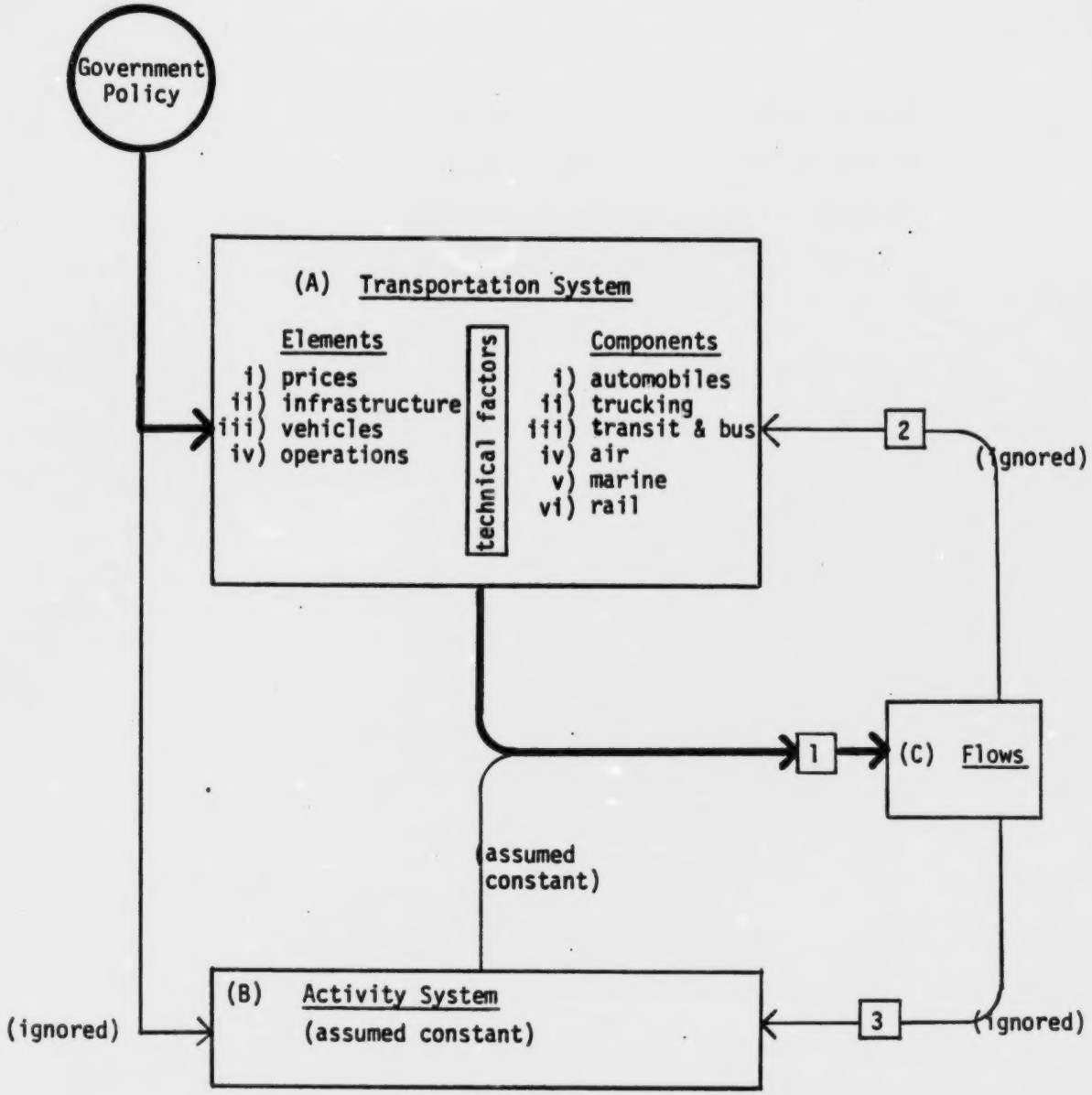



Figure 1.2: CONCEPTUAL FRAMEWORK: SCOPE OF STUDY

boats, snowmobiles, etc.; and, what may be thought of as some of the more isolated or unique applications of the main components such as "bush" planes, "off-road" vehicles, local or dedicated train services, etc..

In part to keep the scope of the study manageable, in part to focus on the most important elements of the transportation system, and in part because of data limitations, the scope of this study is limited to the six components of the transportation system shown on Figure 1.2:

i) automobiles[6] - in total, for 1980, there were 10.3 million automobiles in Canada and 13.9 million licensed drivers. Automobiles are estimated to have been driven 172 billion kilometres in 1980 and over half of this driving occurred in urban areas. The total output, bearing in mind that this is a partial measure of output, is estimated at 308 billion passenger-kilometres.

ii) trucking[7] - in 1980 there were something in the order of 2.9 million trucks in Canada; although only a small fraction of these (less than 10%?) were commercial trucks used to haul freight. In many ways, in terms of considering how government policies affect transportation energy efficiency, most of these trucks - the "small" trucks - are best considered along with automobiles. As for that small fraction of the larger commercial trucks used to haul freight, there are no particularly good sources of data to estimate the number of kilometres or the total output. If the "for-hire" component of these large

trucks, for which there is data, is used as a rough guide to extrapolate to that segment for which there is no data, it might be speculated that the larger trucks were driven somewhere around 7 billion kilometres and that the total output of the industry was in the order of 70 to 100 billion tonne-kilometres. (These are very "soft" estimates.)

iii) transit and intercity bus[8] - in 1980, this component of the transportation system operated 39,730 vehicles (56% of which were school buses and 6% of which were electrically-powered vehicles such as subway cars). While information is incomplete, there were over 1.3 billion passengers carried (excluding most school children) and 1.3 billion kilometres driven (including most school buses). One author has estimated that in 1980 urban transit operations accounted for 11 billion passenger-kilometres (about 3.5% of the total for all automobile operations) and that intercity bus operations accounted for 4 billion passenger-kilometres (a little more than rail, about 1.3% of automobile).

iv) air[9] - in total, in 1980, there were about 900 commercial air operators in Canada; although, most of this activity was dominated by the six large airlines and, to a lesser extent, the 33 scheduled foreign carriers. Total commercial air operations in 1980 logged 0.6 billion kilometres and produced 5.4 billion tonne-kilometres of output - or, 48.8 billion passenger-kilometres plus 1.0 billion tonne-kilometres of freight (for all "goods" carried).

v) marine[10] - this component of the transportation system is so diverse that it is difficult to find any industry-wide figures. The domestic, for-hire segment in 1980 consisted of 232 operators with 1,798 vessels (over a 1,000 of which were tugs, barges, and scows). In addition, there were 49 private operators with 549 vessels, and 26 government undertakings with 537 vessels. (There were also international carriers and a wide assortment of pleasure, fishing, and other types of vessels.)

vi) rail[11] - the 33 common rail carriers in Canada operated 4,167 locomotives in 1980 - 3,488 of these by the two major railways (CN and CP). Total train-kilometres were 0.1 billion, and total output was 235.0 billion tonne-kilometres of freight (87% CN and CP) plus 3.3 billion passenger-kilometres.

Some of the information about these six components is summarized on Table 1.1. It is evident that, whatever measure is adopted (vehicles, kilometres, passengers, or volume of freight), the automobile component dominates the transportation system.

Table 1.1

TRANSPORTATION SYSTEM (1980): SCOPE OF STUDY

| Component | Number of Operators | Number of Vehicles | Freight (billion tonne-km) | Output Passengers (billion pass.-km) | Distance (billion km) | Comments |
|---|---|---|---|---|---|---|
| 1. Automobile | 13.9 million drivers | 10.3 million | | 308 | 172 | - "drivers" include truck & other road drivers |
| 2. Trucks<br>- large freight<br>- small<br>- total | | <br><br>2.9 million | 70-100 | - | 7 | - very "soft" estimates; most trucks are "small" |
| 3. Transit & Bus<br>- intercity<br>- urban<br>- school<br>- other | <br>54<br>76<br>1,554<br>140<br>1,824 | <br>1,842<br>12,685<br>22,306<br>2,897<br>39,730 | | <br>4<br>11<br><br>? | <br>0.20<br>0.66<br>0.33<br>0.09<br>1.28 | - vehicles & output are shown by the classification of the enterprise; some figures are incomplete |
| 4. Air | 900 | | 1 | 48.8 | 0.6 | |
| 5. Marine<br>- for hire<br>- private<br>- government<br>- total | <br>232<br>49<br>26<br>307 | <br>1,798<br>549<br>537<br>2,884 | | | | - domestic for-hire, private, & gov't. operations only |
| 6. Rail<br>- CN, CP<br>- other<br>- total | <br>2<br>31<br>33 | (locomotives)<br>3,488<br>679<br>4,167 | <br>205<br>30<br>235 | <br>0.1<br>3.2<br>3.3 | (train-km)<br>0.10<br>0.04<br>0.14 | - common rail carriers only |

## Notes to Chapter 1

1. As one example, see Canadian Transport Commission [5].

2. Transport Canada [24].

3. Evidence of this type of thinking may be found in Transport Canada [24]. This study recognizes that fuel use by the transport sector is sensitive to price increases, but is concerned that the expected increases over the next decade will not be high enough to ensure the "zero-growth target": " . . . the implication of this study is that policies will have to be considered to induce the desired long-term level of fuel consumption".

4. The conceptual framework has been developed from M. L. Manheim [65].

5. Economic Council of Canada [7], Chapter 2.

6. Statistics Canada [15] and D. J. Reynolds [87].

7. Statistics Canada [16,17] provides data on the for-hire component: 61 thousand trucks, 3.5 billion kilometres, and 41.7 billion tonne-kilometres. Very shortly, Statistics Canada will also be making available the results of its first private trucking survey. In the absence of these figures, the numbers in the text have to be regarded as speculative; although one author, D. J. Reyholds [87] has provided a total estimate of truck output at 71 billion tonne-kilometres. The definition of a "small" truck varies from one source to another; possibly a total registered weight of less than 4,500 kg is as useful a definition as any other.

8. Statistics Canada [14], and D. J. Reynolds [87].

9. Statistics Canada [9].

10. Statistics Canada [18]. Also, H. J. Darling and G. C. Shaw [38] present some earlier data on the Great Lakes shipping industry.

11. Statistics Canada [11, 12, 13].

## Chapter 2 Transportation and Energy

### 2.1 Purpose of Chapter

The purpose of this Chapter is to provide an elementary understanding of the transportation system and its use of energy. This is necessary in order to understand the broader question of how government policies affect energy efficiency. The subject of transportation and energy is covered in a great amount of detail in a large number of other studies and reports. This Chapter provides only a brief summary of this material under six headings.

i) Consumption Considerations

The first step in examining how government policies affect energy efficiency is to determine how much energy each component of the transportation system consumes. This allows the study to concentrate on the relatively more important components.

ii) Supply Considerations

Some government policies have the effect of influencing the supply of energy or a particular source of energy for some components of the transportation system. The issue is whether or not these supply considerations can be included within the scope of this study.

iii) Technical Considerations

The effect of government policies on transportation energy efficiency have to be understood in terms of the basic technical factors determining energy efficiency.

iv) Cost Considerations

In assessing the importance of some government policies on different components of the transportation system, it is helpful to consider the relative level of energy costs compared to total costs and variable (or "running") costs.

v) Transportation Demand Considerations

This study has assumed that the activity system remains constant. In effect, this means that the demand for transportation is for a given set of tastes, preferences, income levels, etc. While not considered in this study, it must at least be noted that government policies can affect the activity system and that, in turn, these changes in the activity system can affect transportation energy efficiency.

vi) Energy Demand Considerations

In attempting to understand how government policies can affect transportation energy efficiency, it is important to know something about the transport operators' demand for energy.

## 2.2. Consumption Considerations

Table 2.1 shows the estimated energy consumption of various components of the transportation system for 1980. Since

Table 2.1

TOTAL TRANSPORTATION FUEL CONSUMPTION: 1980

| | | Million Litres | % |
|---|---|---|---|
| 1. | Automobile - urban | 16,172 | 29.5% |
| 2. | - rural | 9,176 | 16.8% |
| 3. | - total | 25,349 | 46.3% |
| 4. | Trucks - light trucks (excl. agriculture) | 8,475 | 15.5% |
| 5. | - light trucks (etc.) - agriculture | 1,919 | 3.5% |
| 6. | - medium & heavy (excl.for-hire) | 5,530 | 10.1% |
| 7. | - medium & heavy - for-hire | 2,020 | 3.7% |
| 8. | - total | 17,944 | 32.8% |
| 9. | Transit & Bus - intercity bus | 90 | 0.2% |
| 10. | - urban transit | 243 | 0.4% |
| 11. | - school bus | 164 | 0.3% |
| 12. | - other | 41 | 0.1% |
| 13. | - total | 538 | 1.0% |
| 14. | Sub-Total: Road Components | 43,830 | 80.0% |
| 15. | Air - Level I & II (Air Can.,CP, regionals) | 3,325 | 6.1% |
| 16. | - Level III - V | 621 | 1.1% |
| 17. | - scheduled foreign | 355 | 0.6% |
| 18. | - all other (Level VI & VII, general aviation | 512 | 0.9% |
| 19. | - total | 4,813 | 8.8% |
| 20. | Marine - foreign carriers - international | 1,632 | 3.0% |
| 21. | - domestic for-hire carriers | 1,136 | 2.1% |
| 22. | - domestic private carriers | 186 | 0.3% |
| 23. | - government carriers | 351 | 0.6% |
| 24. | - other (fish.,gov't service,pleasure) | 397 | 0.7% |
| 25. | - total | 3,702 | 6.8% |
| 26. | Rail - freight | 2,031 | 3.7% |
| 27. | - passenger | 200 | 0.4% |
| 28. | - yard switching & work train | 205 | 0.4% |
| 29. | - total | 2,435 | 4.4% |
| 30. | Grand Total | 54,780 | 100.0% |

there are difficulties in obtaining data for these estimates, since these are debatable numbers, and since assumptions have been used, a detailed explanation is contained in the notes to this Chapter.[1] These difficulties aside, there are several important points to note about these figures.

Contained within the column showing the total litres of fuel consumed are various types of petroleum-derived fuel. If the energy content - the units of energy per litre of fuel -had been used instead of the simpler volumetric measure, the percentages shown in the second column would be somewhat different. While this "energy content" method of showing energy consumption would be an improvement, this level of detail is not required here.

The most striking aspect of the figures shown on Table 2.1 is the relative importance of some components of the transportation system in comparison with other components. In particular, automobiles account for 46% of the total transportation fuel consumption (derived from petroleum). If the "light" trucks" - roughly trucks weighing less than 4.5 tonnes - were included with automobiles, these two components

account for over 65% of total transportation fuel consumption. (These two components of the transportation system - automobiles and small trucks - are similar in many respects, and are often treated as a one homogeneous component in this report.) It is apparent that government policies affecting this automobile/small truck component have potentially a much greater impact on total transportation energy efficiency than any other policies affecting other components.

This same observation can be made in another way. Specifically, it is apparent that some components of the transportation system account for so little fuel consumption, that the relative importance of policies affecting these components is almost negligible.

These observations may be controversial. For this reason, consider the following illustration. Suppose two government policies had the effect of increasing or decreasing the energy efficiency of two components of the transportation system by the identical amount of 1%. How important are each of these policies if the two components were automobiles and intercity passenger trains? A 1% change in the fuel consumed

by automobiles is, by itself, more fuel than the entire amount of fuel consumed in a year by all intercity passenger trains now operating in Canada. Conversely, a 1% change in fuel consumption by passenger trains represents less fuel than the amount now consumed by all automobiles in one hour (assuming total automobile fuel consumption was spread out evenly throughout the year).

## 2.3 Supply Considerations

This study does not consider those government policies which affect the supply of energy. Having said this, however, it must be admitted that it is difficult to ignore "supply-side" issues. These difficulties arise when some government policy favors or encourages the use of one type of fuel over another and, as a consequence, there are changes in transportation energy efficiency.

For example, a policy might encourage propane-powered automobiles over gasoline-powered. In assessing the impact of this policy it has to be determined, among other things, whether efficiency is to be measured as the cost of the fuel consumed per unit of output, the

volume of fuel consumed per unit of output, or the energy content of the fuel consumed per unit of output. Having noted that it is the technical efficiency of production which is at issue here, the first of these three choices can be eliminated. However, and assuming a choice could be made between the two remaining alternatives, it would not seem to be particularly relevant to label a government policy as having a negative impact on efficiency - assuming this to be the case with propane - when it is the gasoline-type of fuels which are in short supply and when there is more propane available than can be used domestically.

Another example, which adds one more complication, would be a policy which encouraged the use of diesel fuels rather than gasoline fuels. Here, it is not just the price of the two types of fuels which introduce complications, it is also the fact that the inherent characteristics of the two engines which burn these fuels are different. Under most circumstances, a diesel engine is more efficient than a gasoline engine - no matter whether efficiency is measured volumetrically or on the basis of the energy content per unit of output. Is it correct to label a government policy which encourages the use of diesel

as having a positive impact on efficiency when a quick check of the "supply-side" considerations show that it is the distilates from which diesel is derived that are probably going to be in shorter supply than the gasoline range of distilates? Such a conclusion, while possibly "technically" correct, would seem to require at least some qualification.

## 2.4 Technical Considerations

The question of how a government policy, or any other factor affects the energy efficiency of a transportation system has to be addressed by considering the basic technical factors which determine energy efficiency. It is difficult to provide an adequate description of these technical factors in a few pages. However, the following brief notes provide the minimum level of technical detail that are necessary to understand later Chapters.

Transportation is the movement of people or goods in a certain manner (or, with certain "service characteristics" such as speed, degree of safety,

etc.). The components of the transportation system under consideration in this study all have the following features in common:

i) a payload: that is, people or goods

ii) a vehicle: that is, an automobile, truck, plane, ship, train, etc.

iii) a propulsion system: that is, something (for example, an engine) which converts the stored energy in fuels into mechanical energy. For various types of vehicles, there are various mechanisms (transmission, wheels, etc.) required to channel this mechanical energy into "transportation work".

iv) a fuel: that is, for this study, almost all of the fuels considered are petroleum-based. These fuels are a convenient source of storing heat or thermal energy.

Transport "work" can be defined as the displacement or movement of a payload between two points: the "work" performed is in overcoming the resistance that opposes this displacement. In scientific terms "work", or force times distance, is equivalent to "energy". The aspects of this movement of payload which are of interest in this study are:

i) resistance: the more resistance to be overcome, the more work (or energy) is required.

This study is interested in instances of where government policies have an impact on the amount of resistance to be overcome.

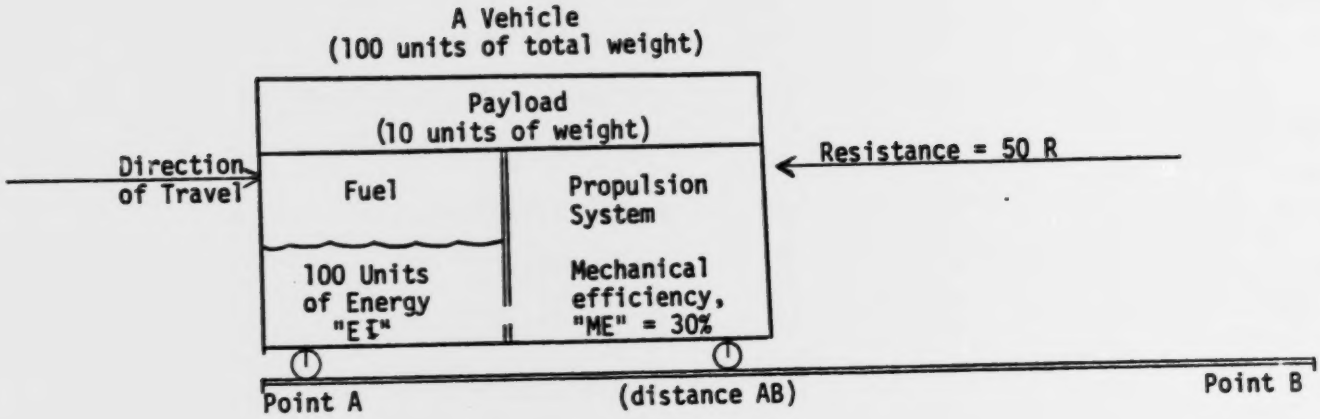
ii) mechanical efficiency: a measure of the efficiency of the propulsion system; it is the ratio of useful work output as compared to the energy input.

This study is interested in instances of where government policies have an impact on the mechanical efficiency of a propulsion system.

iii) payload/gross weight ratio: the total resistance to be overcome is related to, among other things, the total weight of the vehicle plus payload. However, transportation work is only defined in terms of the payload carried. Therefore, anything which increases the ratio of payload to gross weight - everything else held constant - decreases the amount of work (energy) per unit of payload.

This study is interested in instances of where government policies have an impact on the payload/gross weight ratio. This translates into one of two situations: (a) instance of where the weight of the vehicle - the "tare" weight - is held constant and the payload is increased; or, (b) instance of where the payload is held constant and the tare weight is reduced.

A simple schematic diagram, shown on Figure 2.1, will make it easier to understand the four common elements of transportation systems and the three technical factors affecting energy efficiency.




i) "Transport Work" = 10 units of payload x distance AB

ii) "Transport Output"(TO) = Transport Work at a certain "Service" level

iii) "Energy Input" (EI) = 100 units of energy

iv) "Transportation Energy Efficiency "(TEE) = $\frac{\text{Transport Output (TO)}}{\text{Energy Input (EI)}}$

v) Total energy required to move a mass of 100 units, experiencing a resistance of 50R, a distance of AB is assumed to be 30 units of energy.

vi) If resistance can be lowered, total energy required decreases and the "Energy Input" in the efficiency equation decreases thereby increasing TEE.

vii) If mechanical efficiency can be increased, the propulsion system uses less fuel to deliver the 30 units of energy required. The "Energy Input" in the efficiency equation decreases thereby increasing TEE.

viii) If vehicle tare weight could be reduced to 89 units of weight and payload increased to 11 units, transport work is increased and (assuming "Service" remains the same) the "Transport Output" in the efficiency equation increases thereby increasing TEE.

Figure 2.1: TRANSPORTATION SYSTEMS:

TECHNICAL FACTORS AFFECTING ENERGY EFFICIENCY

Reconsidering the discussion in Chapter 1 on the concept of "transportation energy efficiency", the question that now arises is whether or not this concept can be related to these three technical factors. The answer is "yes", if some simplifications are allowed: some of these simplifications are shown on Figure 2.1.

Transportation energy efficiency was defined in Chapter 1 as the ratio of the "transport output" to the "energy input". This is shown in relationship (1).

$$TEE = \frac{TO}{EI} \quad \ldots\ldots\ldots\ldots (1)$$

Recall that the discussion in Chapter 1 centered on the difficulty of defining and measuring the numerator in this ratio. Although this difficulty cannot be overcome, it is useful to separate "transport output" into two terms: "transport work" and "service". "Transport work" can be defined as the movement of payload between two points, or payload times distance. In more scientific terms, work is the application of force times the displacement measured in the direction of the force; as long as the force and displacement are in the same direction, work equals force times distance. The notion of "transport work" defined as "payload times distance" really means

the force used to move a payload a certain distance. "Service" can be defined as those hard-to-measure factors which define the quality or type of transportation service (speed, safety, convenience, etc.). For here, this second term will simply be labelled "service" without any further attempt at quantifying it. The numerator in relationship (1) may now be written as follows:

$$TO = (\text{payload} \times \text{distance})(\text{service}) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The denominator, the energy input, can be measured in a variety of ways (quantity of fuel, energy consumed, etc.); for here, the important point to note is that the amount of this energy input is determined by two technical factors - the total resistance to be overcome, and the mechanical efficiency of the propulsion system.

$$EI = F\,(R, ME) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The original relationship in (1) can now be rewritten as:

$$TEE = \frac{(\text{payload} \times \text{distance})(\text{service})}{F\,(R, ME)} \quad . \quad . \quad . \quad . \quad (4)$$

In most cases where this efficiency is actually expressed in quantifiable terms, for example "passenger-kilometres per megajoule" (or passenger-miles per BTU), the "service" factor

in the numerator is omitted. In these cases, it is really TWEE (transport work energy efficiency) and not TEE which is being measured. However, if the assumption can be made that "service" is held relatively constant, it will be convenient in many cases to consider TEE = TWEE. The quantitative work undertaken for this study has been restricted to measures of TWEE; the omission of the "service" factor has meant that comparisons between the energy efficiency of two transportation services have generally been avoided - particularly in those situations where the service is provided by different components of the transportation system.

Ideally, this study is interested in situations where, with the numerator in relationship (4) held constant, government policies affect one or more of two factors in the denominator; or, in situations where government policies affect the payload/gross weight ratio. In the real world, there are few simple one-to-one relationships. That is, there are few policies which affect only resistance, or only mechanical efficiency, or only payload/gross weight ratios. Furthermore, each of these technical factors is far more complex than the description provided here would suggest, and there are complicated interrelationships among these technical factors. Some further details on this subject are provided in Appendix B.

## 2.5 Cost Considerations

To consider the impact of some government policies on the transportation energy efficiency of any component of the transportation system, it is useful to examine the importance of energy costs for that component. While a great deal of information is available, or could be developed on this subject, for this study only the readily available sources have been used. The findings from these sources are shown on Table 2.2.

It is apparent, from the figures shown on this Table, that fuel costs are a significant proportion of the total costs of the transportation system. (The importance of fuel costs would be even more apparent if there had been available sources for developing fuel costs as a percent of running costs for all components of the transportation system for 1982.)

While these observations by themselves do not provide the "hard" or quantifiable information necessary to assess the impact of some government policies, they are a very important source for some of the "qualitative" judgements which have to be made. Specifically, the figures shown on Table 2.2 suggest that most operators have a fairly strong incentive to adopt "fuel saving" technologies or operating practices.

Table 2.2

FUEL COSTS AS PERCENTAGE OF TOTAL OPERATING COSTS*

| | Year | Fuel Costs as % of Variable Costs | Fuel Costs as % of Total Costs | Sources/Comments |
|---|---|---|---|---|
| 1. Automobiles | 1982 | 82.7% | 26.4% | - Canadian Automobile Association [ 30 ], assumes the typical car operates 15,000 km. per year. |
| 2. Trucks - light | | | | - No information, probably similar to automobiles |
| 3. - medium & heavy | 1980 | 23.3% | 10.8% | - Statistics Canada [ 16 ], figures shown are for for-hire freight carriers only; figures should be treated as approximations. |
| 4. -"typical" 5-axle, dry freight | 1982 | 22%-39% | 14%-24% | - Transport Canada [ 95 ], figures shown are Trimac costing data for a "typical" 5-axle, semi-trailer combination, hauling dry freight, on paved roads, operating 160,000 km. annually. The lowest % are in Alberta, the highest in Newfoundland. |
| 5. Air | 1980 | 26.3% | 23.2% | - Statistics Canada [ 10 ], figures are for Canadian scheduled carriers only. |
| 7. Marine | 1979 | | 14.1% | - Transport Canada [ 24 ], for-hire carriers only. |
| 7. Rail | 1980 | | 8.0% | - Statistics Canada [ 11 ] |

* Further comments on sources are contained in Note #2 to this Chapter.

## 2.6 Transportation Demand Considerations

Referring back to the conceptual model developed in Chapter 1, the statement was made that government policies obviously have an impact on the activity system which, in turn, affects the demand for transportation and which, ultimately, has a bearing on the amount of energy consumed by transportation flows.

An example of this type of relationship would be policies which affect land use. In particular, the basic spatial relationships between residential areas, commercial areas, industrial areas, and so on, are often determined by municipal zoning laws, or decisions of higher levels of government to foster the growth of certain areas or to encourage certain types of industries to locate in certain areas. These policies, then, are instrumental in shaping the amount and type of demand for transportation services. Some policies could be judgedto have a greater or lesser effect on the demand for "single-occupancy , peak hour, relatively long distance" automobile trips, while other policies could be seen as having an effect on the demand for "high occupancy, staggered hours, short distance" trips by transit vehicles (buses, subways, etc.). Clearly, these two types of demand will give rise to different amounts of energy being consumed per "person-trip".

There are many other examples: government policies on agriculture affect the demand for the movement of various types of products (livestock, for example, in comparison to grain) at various times of the year; government polices on interest rates which, among other things, affect shippers' demands for certain inventory levels and, consequently, their demand for relatively few "large" shipments or relatively many "small" shipments; etc., etc.. The difficulty in considering these policies is that once the basic elements of the activity system are changed - or, to use the economist's words, once the factors that affect the position and shape of the "demand curve" change, there is no end to the possible outcomes that may occur.

For this study, then, the activity system is considered "fixed" or "frozen". In practice, of course, it is not always possible to be quite so rigorous. Therefore, it is probably more accurate to state this condition in the following terms: this study is concerned with government policies which affect the transportation system (prices, infrastructure, vehicles, operations); as much as possible, comments on the impact of these policies will be made under the assumption that the acitivity system and, hence, the factors such as "tastes", "preference", "income levels", and so forth are relatively constant. Policies which are directed primarily or solely

at the activity system are not considered.

## 2.7 Energy Demand Considerations

This study isnot directly concerned with the issue of the demand for energy. Yet, indirectly, this subject has a very important bearing on the issues which are of concern. Specifically, to help put the relative importance of government policies into perspective, it is crucial to understand that transport operators themselves may have far more control over energy efficiency than all government policies combined.

This issue is so pervasive to the subject at hand that many aspects of this consideration have to be dealt with in subsequent sections of the report. For here, only a few salient points need be noted. First, and foremost, attention has to be drawn to the growing evidence that transport operators are highly sensitive to significant increases in the real price of energy.[3] In more technical terms, the long run price elasticity of demand for transportation fuel may well be in the range of -1.0 to -2.0. ( In effect, these measures of elasticity suggest that a given percent increase in real energy prices will result in an equal to double percentage decline in the demand for energy - all other factors held constant.) Second, one of the

methods a transport operator may use to reduce energy demand is to adopt more energy efficient vehicles or practices.

While the possibility that the long-term elasticity of demand does not guarantee an increase in transportation energy efficiency (that is, transport operators could simply reduce the amount of transportation), there is good evidence that improvements to efficiency play a large role in the reaction to energy price changes. Later Chapters will discuss some of this evidence.

The important point here (prior to considering any specific policy areas), is that the impact of all government policies on transportation energy efficiency has to be seen in light of the possibility that the transportation system itself will make significant efficiency adjustments in response to energy prices. (Energy prices themselves, of course, may be determiend largely by government policy.) If this point is not established at the outset, there exists the very real danger that this study will imbue a sense of exaggerated importance to many policy areas.

## 2.8 Summary

This Chapter has only given a brief description of six considerations on transportation and energy. Nevertheless, these descriptions are sufficient to make some statements on the subject of the impact of policies on transportation energy efficiency even before describing or analyzing these policies.

First, it is clear that government policies affecting automobiles and light trucks have a far greater potential for having a major impact on efficiency than policies affecting any other component, or even all other components combined.

Second, while the study is not directly concerned with policies affecting the supply of energy, it is true that some "supply-side" issues have to be considered in evaluating some policies.

Third, the discussion of the technical factors determining energy efficiency, although not doing full justice to the complexities of the subject, serves to point out the three areas where policies can impact transportation

energy efficiency: resistance to motion; mechanical efficiencies of propulsion systems; and payload to gross weight ratios.

Fourth, the brief consideration of the realtive cost of energy to total transport costs is sufficient to demonstrate that the transport sector has a strong incentive for seeking ways of using energy more efficiently.

Fifth, although the study does not evaluate policies affecting the demand for transportation directly, it is to be appreciated that these policies can affect efficiency. (Later Chapters will also reveal that it is difficult to consider some policies which affect the supply of transportation without also discussing some aspects of demand.)

Sixth, whatever the actual impact of specific policy areas, some sense of perspective must be maintained about the relative importance of this impact in comparison to how the transportation system itself may adjust its energy efficiency in response to energy price changes. This last point, in effect, gives rise to the possibility that one policy area - energy pricing - is being prejudged. As later Chapters demonstrate, there is some evidence (not perfect evidence) for warranting this prejudgement.

## Notes to Chapter 2

1. Total fuel consumption for each of the six components of the transportation system was taken from a study by Transport Canada [24], which used Statistics Canada [19] as a starting point. From this source, the following adjustments and/or further sources were used to disaggregate the figures:

   i) Automobiles - two small adjustments were made to the Transport Canada figures to "force" the total fuel consumption to add to 54,780 million litres: (a) 109.5 million litres were transferred from automobiles to the transit and intercity bus component, and (b) a further 6 million litres were deducted to "force" the total. The allocation of automobile fuel consumption to "urban" and "rural" driving was made on the basis of an estimated split in urban and rural driving of 52:48 (D. J. Reynolds [87] and an assumed fuel consumption rates of 14 mpg in urban areas and 23 mpg in non-urban areas (4.96 km/L and 8.14 km/L, various sources). No adjustment was made to account for the fact that Transport Canada's figures probably include 400-500 million litres of fuel used for agricultural purposes.

   ii) Trucks - Transport Canada's figures showed two categories of trucks: light trucks (up to 5 tons), and medium and heavy trucks. The figure shown for "light trucks-agriculture" on Table 2.1 is an estimate based on a discussion with the authors of the Transport Canada study. The fuel consumption of the medium and heavy truck category was disaggregated on the basis of Statistics Canada's figures [16] for the for-hire segment.

   iii) Transit & Intercity Bus - in this case, Statistics Canada's figures [14], were used in preference to Transport Canada's, with the result that 109.5 million litres of fuel were transferred from the automobile component of the transportation system to the transit & intercity bus component. Electricity used by this component has been omitted.

   iv) Air - Transport Canada's figures have been used for the total, and Statistics Canada's figures [9] have been used to disaggregate the total with the residual being allocated to line 18 of Table 2.1. (Some of the fuel shown for Level I to V carriers was purchased outside of Canada.)

   v) Marine - two Statistics Canada sources [18, 19] were used to disaggregate the total. As these sources are not entirely compatible, the residual was allocated to line 24 of Table 2.1.

vi) Rail - Transport Canada's figures were used for the total, and Statistics Canada's figures [12] were used to proportionately allocate this total to lines 27, 28, and 29 on Table 2.1. Electricity was omitted.

2. Source of figures shown on Table 2.2:

i) Automobiles: The Canadian Automobile Association [30] suggests that for 1982, for a car operating 15,000 km per year, fuel costs are 8.06¢/mile out of total running costs of 9.75¢/mile and total costs of 30.50¢/mile.

ii) Trucks: Statistics Canada [16] shows for 1980 that for-hire freight carriers spent $449.5 million on fuel (including taxes). These carriers reported total operating expenses of $5,060.1 million. Because of the fact that some fuel expenses are "buried" within the accounts showing expenses for owner-operators and piggyback operations, the percentage shown on Table 2.2 (10.8%) has been calculated with these two expense items deducted from total operating expenses. Similarly, the percentage shown for fuel costs as a percent of variable costs has been calculated as total fuel costs over what Statistics Canada shows as "total transportation expenses" less expenses for owner-operators, piggyback, and depreciation of revenue equipment. The Trimac figures shown have been selected from a very wide range of figures available (different types of equipment, different annual distances, paved versus gravel road, different commodities). The percentage for straight truck operations would be somewhat lower, the percentages for bulk commodity operations would be somewhat higher, etc. The "typical" 5-axle, dry freight van may be considered one of the more common types of intercity vehicles.

iii) Air: Statistics Canada [10], Table 7, shows, for Canadian scheduled air carriers for 1980, total fuel (and oil) expenses of $694.5 million, and total expenses of $2,990.0 million. Although there is undoubtedly a finer calculation of variable costs which could be made, for Table 2.2 they have been calculated as total operating expenses less depreciation and "general services and administration" ($2,640.2 million).

iv) Marine: the figures shown in the Transport Canada study [24], are from Statistics Canada [18].

v) Rail: Statistics Canada, [11] shows for 1980 total fuel expenses (excluding electric) at $402.1 million and total railway expenses at $5,003.0 million.

3. The conventional wisdom in Canada has been that the short-term price elasticity for energy is in the range of -0.1 to -0.2, and the long-term elasticity in the range of -0.4 to -0.9. However, more recent evidence suggests that long-term price elasticities might be much higher than this. See, for example, D. R. Boki [2], R. S. Pindyck [79], or J. M. Griffen [46].

# Chapter 3 Classification of Government Policies

## 3.1 Purpose of Chapter

As discussed in Chapter 1, "government policy" is defined as each and every "thing" done by the three levels of government which has the potential for affecting transportation energy efficiency. This concept of policy includes not only all legislative measures (acts, regulations, bylaws), but also all of the literally thousands of "programs", "standards", and "actions" which governments administer on a day-to-day basis.

Identifying and assessing the impact of each and every one of these policies is not possible. For the purposes of this study, it was necessary to develop a classification scheme which would permit a rational ordering of policies. The purpose of this Chapter is to present such a scheme.

## 3.2 Policy Perspectives

### 3.2.1 Sources

Policies which may affect the transportation system emanate from a wide variety of sources within the three levels of government. The main sources are shown on Table 3.1.

Table 3.1

SOURCES OF POLICY

| Level of Government, Department/Agency | Types of Policies Affecting: | | | | | |
|---|---|---|---|---|---|---|
| | Automobiles | Trucks | Transit & Intercity Bus | Air | Marine | Rail |
| **Federal** | | | | | | |
| 1. Transport Canada<br>- including various Administrations (Surface, Air, Marine, etc.); the Transportation Development Centre; etc. | - Wide range of "strategic" policies affecting all components of the transportation system<br>- R & D role (vehicles, infrastructure, operations) affecting all components<br>- Other programs (e.g., cost-sharing with the provinces on highway projects; etc.)<br>- New vehicle safety standards, emissions, fuel consumption guidelines | - Dangerous goods . . . | | - Operates airports; air traffic control; etc. | - Policies affecting ports, coastguard (navigation, safety) | - Various policies |
| 2. Canadian Transport Commission (CTC) | | Limited regulation | Limited regulation | Regulates | Limited regulation | Regulates |
| 3. Energy, Mines & Resources (EM & R) | - Concerned with energy used by the transportation system (R & D, development of standards) | | | | | |
| 4. Finance | - All federal tax policies affecting the transportation system (e.g., sales taxes, custom duties, investment tax credit, etc.) | | | | | |
| 5. Other | - A large number of other departments/agencies: e.g., National Research Council (R & D); Foreign Investment Review Agency (ownership); Public Works (federal roads); Environment Canada (sets emission standards); Industry, Trade & Commerce (e.g., programs affecting vehicle manufacturers); Consumer & Corporate Affairs (competition policy); etc. | | | | | |
| **Provincial** | | | | | | |
| 6. Highways, Transportation etc. (various names in different provinces) | - Builds, maintains, regulates the use of roads<br>- Vehicle standards, registration, driver licensing, regulation | | | -In some provinces, there is some role with air, marine, & rail (e.g., those segments under provincial jurisdiction, some ownership, providing infrastructure, etc.) | | |
| 7. Regulatory Boards | | Regulates | Regulates<br>Also, with #6 and federal departments, participates in programs aimed at achieving uniformity among provinces | | | |
| 8. Finance (Revenue, etc.) | - Provincial tax policies (e.g., fuel taxes, sales taxes, and various other vehicle/driver/infrastructure fees) | | | | | |
| 9. Other | - A wide variety of other departments/agencies: e.g., in some provinces ministries or departments of energy (promotion, use of, etc.); departments of industry and/or commerce (grants, location, promotion); some R & D role; some input to federal policies; and a large number of other departments/agencies (agriculture, labour, marketing boards, etc.) whose actions affect the transportation system. | | | | | |
| **Local (Municipal, etc.)** | | | | | | |
| 10. Various Depts. | - Builds, maintains, regulates urban ("local") roads; these roads account for about 2/3 of all roads in Canada; there is usually an input to this role from other levels of government. | | Operates most transit systems | -Some input to policies (e.g., local infrastructure) | | |

### 3.2.2 Mechanisms

Various policy mechanisms are employed by these government bodies, including:

- the promulgation, administration and enforcement of legislation, regulations and bylaws impacting the characteristics of the transportation system.

  This legislative envelope ranges from policies as large and pervasive as the "National Transportation Policy" to something as minute and isolated as a village bylaw legitimizing a stop sign on a residental street.

- the financing, taxation and subsidization of various aspects of the transportation system.

- the development and propagation of various "standards", over and above legislative-derived standards, which influence the characteristics of the transportation system.

  Particulary important "standards" of relevance to the energy question relate to engineering design-type "standards" pertaining to physical infrastructure, such as roads.

- the development and administration of various "programs", usually within the boundaries of a broad legislative envelope.

  Significant program categories of relevance to the energy question include programs involving voluntary guidelines, promotional and educational programs, and R and D programs.

### 3.2.3 Intentions

The vast majority of the policies which impact transportation energy efficiency have no principal intention of doing so. These policies are usually directed at other objectives, such as "energy self-sufficiency", "public health and safety", "environmental protection", "economic/service" considerations, and "equity" considerations.

### 3.2.4 Timeframe

Government policies vary in terms of time periods required for them to be implemented or for them to have an impact.

For example, a change in speed limits on roads can be implemented in a very short period of time and (if enforced) have an immediate effect on energy efficiency. The introduction of fuel economy standards for automobiles and/or trucks takes a longer period of time to implement: manufacturers have to be given enough time to adjust. Further, the impact of such a policy takes even longer to be felt as the existing stock of vehicles is only gradually replaced by newer vehicles. Finally, some broad policy directives such as the National Transportation

Policy take literally decades to be implemented and to have any impact on the transportation system, as institutions and practices change only very slowly.

### 3.2.5 Interdependence

The complex interdependence of policies is another factor to be considered in developing a classification scheme.

To illustrate, government transport investment policies (which are, to some extent, dependent on such government revenues as those derived from fuel taxes) play a major role in determining infrastructure characteristics (the number of roads, the quality of roads, the size of ports, etc.). These infrastructure characteristics, in part, influence the government policies on operational rules (speed limits, curfews at airports, etc.). Some aspects of operational rules affect vehicle design and, hence, vehicle prices. Vehicle prices, in turn, have an effect on tax revenues and, to the extent government expenditure policies depend on tax revenues, this may influence government transport investment policies.

Clearly, there is no obvious place to stop or start this chain of interdependencies. Is the speed limit on a

highway the cause or the effect of infrastructure standards? are vehicle design features the cause or the effect of taxation policies? Such questions are probably unresolvable.

This reality of massive policy interdependency also influenced the development of the policy classification system selected for this study. The basic influence was a requirement to stipulate a system which would, in a partial sense, permit the "breaking" of the chain so as to facilitate manageable analysis of impacts.

## 3.3 A Classification Scheme

The previous section has briefly examined a number of perspectives that can be brought to bear in developing a policy classification scheme.

i) Sources: policies emanate from a wide variety of sources and there is no simple, non-overlapping method of organizing sources with components of the transportation system.

ii) Mechanisms: there are various mechanisms used to effect policies, and the dividing line between different mechanisms is not always clear.

iii) Intentions: few policies are implemented with any specific intent to have an impact on transportation energy efficiency.

iv) Timeframe: there is an infinite spectrum of timeframes which have to be considered.

v) Interdependence: there is no obvious place to "break into" the chain of interdependency between policies.

The complexity of these matters makes it difficult to devise a classification scheme for policies which serve all purposes. Adding to this complexity are the perspectives that many people involved with the transportation system have developed given their role in the system (a shipper, an operator, a regulator, etc.); the perspectives developed from "modal" biases (road versus rail, etc.); the perspectives inherent to different regions (rural versus urban, etc.); and other perspectives. No one classification system can satisfy all of these complexities and/or perspectives.

For this study, the following classification scheme is adopted.

- policies affecting prices, including both transportation input prices (vehicles, fuel, infrastructure) and transportation service prices (fares, rates, etc.).

- policies affecting infrastructure, such as roads, airports, harbours, traffic control systems, etc.

- policies affecting vehicles (automobiles, trucks, buses, planes, vessels, trains).

- policies affecting operations (routing, speed, flow quality, operator skill, loads, service, etc.)

To the extent possible, each policy class - and subclassifications within each group - is discussed as if everything else is held constant. It will be observed, however, that in some cases this attempt to isolate policies within a class (with everything else assumed "frozen") has to be relaxed. At times, the system and/or the process simply does not make sense without some relaxation of the classification system - particularly where complex interdependencies or data sources make it difficult to be quite as rigorous as this scheme demands.

## Chapter 4 Policies Affecting Prices

### 4.1 Purpose of Chapter

This Chapter examines government policies affecting transportation input prices (fuel, vehicles, etc.) and transportation service prices (fares, rates, etc.). The examination is limited to those policies affecting prices where there is some potential for prices to affect transportation energy efficiency.

Considering input prices, it is to be noted that policies may affect prices directly (for example, a tax on fuel) or indirectly - in the sense of changing the cost of purchasing an input (for example, a capital cost allowance or an investment tax credit). Since it is only those input prices which have a potential for affecting energy efficiency which are of interest, the focus here is on three types of input prices: i) fuel prices; ii) vehicle prices, including all associated vehicle parts; and iii) infrastructure prices, or "user fees" as they are generally referred to in the case of government-supplied infrastructure and the cost of building infrastructure in other cases (for here, these other cases are almost all related to rail infrastructure.) Other input prices are ignored on the assumption that they do not have a significant impact on energy efficiency.

With respect to service prices, the two primary issues of interest here are the regulation of rates by government and transportation subsidies (which affect rates). Although there are other areas where government policies may affect service prices - for example competition policy, these are not examined.

## 4.2 The General Effect of Prices

In terms of the producers of transportation services (in effect, all of the "commercial" components of the transportation system), prices govern the choices made with respect to the combination of inputs used to produce a service. To illustrate, consider the decisions made when someone starts a trucking operation. This potential entrepreneur could purchase an old truck for $50,000 which will consume fuel worth $25,000 over the course of a year. Alternatively, this person could buy a brand new truck with a diesel engine, aerodynamic devices, radial-ply tires, and other advanced technologies which will cost $100,000 but which will consume only $15,000 worth of fuel, while still producing the same output over the year as the old truck. The relative price levels of fuel, vehicles, and other inputs have an impact on the choices made.

Consumers of transportation services, and here the interest is primarily on the operators of private automobiles (and a good proportion of the small trucks), are also guided by relative price levels. Although many other factors are important for a full understanding of the process which influences consumers' choices (for example, "tastes", "income levels", etc.),in this study these other factors are ignored. (In effect, as discussed in Chapter 1, the activity system is assumed to be held constant.)

Before dealing with actual policies affecting prices, there are a few observations to make about the general effect of the three input prices (infrastructure, vehicles, fuel) and service prices.

### 4.2.1 Energy (Fuel) Prices

The point was made in Chapter 2 that the transportation system's response to changes in energy prices is, or may be, so significant that the subject of energy prices pervades many other areas where the effect of policies on energy efficiency is being considered. There are several aspects of this relationship that must be noted.

The most conventional method of measuring the response to price changes, "elasticities" (or, more correctly, the "price elasticity of demand"), is both of great help and of great hinderance for the purposes of this study. It is of great help in the sense that most of the more recent evidence on the subject suggests that producers and consumers of transportation services are responsive to real price changes. This is a necessary condition for advancing the thesis that the transportation system will adopt more energy efficient technologies and/or practices when faced with price increases. However, it is not a sufficient condition, and this, to some extent, is why elasticity measures can be of some hinderance.

Considering, first, the consumers' reaction to energy price changes (primarily private automobile and lighttruck operators), there are a number of possible responses: only some of these responses are of interest in this study. A rise in energy prices may cause the demand for travel to fall; or, it may cause the demand for a particular type of travel to fall (say, single-occupancy automobile trips) while causing the demand for other types of travel to increase (say, ride-sharing or public transit). While this reaction might be of great interest in a study on "energy conservation", strictly speaking, it is not of interest here. That is, the assumption that the

activity system is constant has been violated and the resulting changes are not purely energy efficiency changes. In particular, the "service" variable in transportation output changes.

Other responses to rising energy prices would include "pure" energy efficiency changes - for example, purchasing more efficient vehicles, adopting more efficient driving methods, engaging in more efficient loading practices (ride-sharing, etc.), and so on. This is where a study on energy efficiency runs into trouble as, in some sense, most of these "pure" efficiency changes can also be seen as changes in the demand for travel. "Ride-sharing", which is clearly a different type of transportation service (than single-occupancy trips), is also a "pure" efficiency change in the sense that the payload to gross weight ratio has been increased. Less obvious, but equally important, examples would include some aspects of the "pure" efficiency changes associated with more efficient driving practices. For example, driving at slower speeds, while clearly affecting energy efficiency, also affects transportation service (that is, longer trip times).

Considering the producers of transportation services (the commercial components), this same confusion arises in

trying to sort out "pure" efficiency changes and changes in the demand for certain transportation services. Ideally, energy price changes should be treated as one of the elements of the transportation system (that is, box (A) in the conceptual framework developed in Chapter 1). The effect of a change in price could then be evaluated in terms of how transport operators adjust their use of other elements to produce more (or less) energy efficient flows. In practice, however, changes in energy prices will affect different components differently with the result that transportation prices may change and, hence, the demand for transportation service may be affected. So, for example, there is some difficulty in knowing whether an increase in energy prices which ultimately leads to more shippers using piggyback (or TOFC) services instead of truck-highway services is a "pure" efficiency change or not.

This difficulty, considering both the private motorist and the commercial producers of transportation, is really one of isolating the effect of energy prices on the transportation system without considering any changes in the demand. It has to be noted that in practice it is rarely possible to do this.

As if these problems did not create enough difficulties, one other must also be noted. At times, energy price changes

which do affect the demand for transporation service continue on to cause "pure" efficiency changes. For example, a sharp rise in energy prices may cause enough people to opt for ride-sharing or public transit that the remaining (fewer) vehicles operating over the road network can operate in a more energy-efficient manner. This is most evident in "less congested" driving conditions.

No known studies (or empirical measures, data sources, etc.) have sorted out all of these interrelated effects. As a consequence, although later sections of this Chapter describe energy-pricing policies, it can be noted here that the energy-efficiency impacts of these policies has to be made in a somewhat judgemental fashion.

### 4.2.2 Vehicle Prices

Sorting out the general effect of policies affecting vehicle (and parts) prices, in terms of energy efficiency, can be just as difficult as energy prices. For here, however, the main interest is to determine where (or if) policies are affecting the relative price levels of more energy-efficient vehicles in comparison to less energy-efficient vehicles. (In many cases, "vehicle prices" have to be understood as the "cost" of purchasing, owning, or using vehicles or associated equipment.)

### 4.2.3 Infrastructure Prices

For many components of the transportation system, infrastructure prices or user charges can be dealt with, in large part, under some aspects of vehicle or fuel prices. That is, some of the taxes (or fees) that affect vehicle or fuel prices are generally considered to be charges levied for the use of government-supplied infrastructure. (There can be some debate as to just how many of these taxes or how much of a particular tax should be regarded as a user fee, but these arguments can be overlooked here.[1])

In considering infrastructure prices and transportation energy efficiency, there are two perspectives of interest. First, the structure of some user charges may encourage more or less energy-efficient vehicles or flows. For example, higher vehicle registration taxes per unit of payload for larger automobiles may encourage some people to buy smaller cars. Second, the total level of all user charges in relationship to the total cost of government-supplied infrastructure may have some impacts on energy efficiency.

Some care has to be taken with this second perspective, generally referred to as "indirect subsidies". That is,

in the first instance, the general level of indirect subsidies for one component of the transportation system or the relative level of indirect subsidies for one component in comparison to another may affect the demand for transportation. For example, the argument has been advanced that because large trucks benefit from a large indirect subsidy, there is more demand for freight transportation by truck than there is for rail (everything else assumed equal). This impact on the relative demand for transportation is not the primary interest here. Rather, the real interest is where these relative demands cause some efficiency-effects on the flows (for example, "congestion"): instances of this happening are probably rare.

### 4.2.4 Service Prices

Finally, the general effect of service prices is straightforward: there is an inverse relationship between changes in price and the quantity demanded. The situations where this can become a factor in considering energy efficiency are probably limited. Consider, for example, a government agency which regulates airline rates. It could be argued that if such an agency permitted airlines to adopt incentive pricing practices the resulting higher load factors meant less energy per passenger than would otherwise have been the case. The difficulty with this argument, however, is

determining whether a 747 with a full load of passengers is really more efficient than a 747 with half a load when it may be that it was only the existence of promotional fares which caused the additional demand for transportation.

## 4.3 Policies Affecting Fuel Prices[2]

At the federal level, the major policy affecting fuel prices is the National Energy Program (NEP), a combination of agreements on scheduled price increases, fiscal measures and expenditure programs. The effect of this policy is to create a single price for crude oil in Canada, subject to transportation differences, which will see the "blended"price of oil rising to about 85% (at Montreal) of world oil prices by 1985. The "Alberta Agreement" of September 1981 established a ceiling for the domestic price of old conventional oil at 75% of world prices which was originally assumed to be reached, given the scheduled price rises, in 1986. It would appear that this ceiling is now going to be reached much earlier.

Also at the federal level, there is a 9% federal sales tax levied on both gasoline and diesel fuels and there is a federal excise tax of 1.5¢ per litre on gasoline.

The excise tax is refundable to those components of the transportation system that use gasoline for commerce. In effect, the only significant component of the transportation system in this study which pays the excise tax is the private, non-commercial motorist.

Another federal policy affecting the price of fuel is the Transportation Fuel Compensation Recovery Charge (TFCRC) levied on oil used in international shipping. (There was, or is, an attempt to levy a similar type of charge on fuel used on international air flights. However, the original tax was withdrawn and some new system is now being contested by the air carriers.) This is a rather complicated issue, and given the relatively small amount of fuel used by Canadian marine carriers on international voyages, the possibility that this levy has any measurable impact on efficiency is remote.

(There are also some federal fuel concession taxes assessed on dealers at airports which represent a form of user fee for government-supplied facilities.)

At the provincial level, there are a variety of taxes on fuel. For gasoline, the average level of these taxes on an ad valorem basis is about 20% to 22% (or about 17% to 18% of the retail price). The exceptions to this are Alberta and Saskatchewan which have no tax (Saskatchewan having removed its tax within the past year), and Quebec where the ad valorem tax is double the average.

Provincial taxes on diesel fuel average about 23% on an ad valorem basis; there are some exceptions such as Alberta which has no tax and some provinces which have higher taxes.

Although propane and compressed natural gas, (and, possibly in the future, liquid natural gas) are not significant sources of energy for the transportation system, it should be noted that the prices of these fuels are also subject to the influence of government policy. At the federal level, the basic price is controlled by the NEP and the agreement to hold the wholesale price of gas at about 65% of the price of crude oil (at Toronto, excluding transportation costs).

At the provincial level, a significant number of provinces do not tax these fuels: five provinces

have no tax on either propane or compressed natural gas (the Northwest Territories, British Columbia, Alberta, Saskatchewan, and Ontario); and three provinces have no tax on compressed natural gas (Manitoba, Quebec, and New Brunswick).[3] The general explanation offered for the absence of a tax is to encourage the switch from gasoline (and, to a lesser extent, diesel) to these relatively more plentiful sources.

Some other provincial measures affecting the price of fuels include taxes on aviation gasoline (most provinces); taxes on aviation turbo (one province); taxes on fuel used by the railways (most provinces); and, taxes on marine fuels (some provinces).

Given the uncertainties in the world oil markets, given the spread in some fuel prices arising from "price wars" and various discounts, and given the various differences in provincial tax rates, it is difficult to draw up a comparative table showing the different prices of fuel for each component of the transportation system. One study which has attempted this[4] shows forecast prices for 1982 (Table 4.1); the study, conducted in late 1981 and early 1982, uses both a "pessimistic" and an "optimistic" forecast which accounts for the spread in the prices shown on Table 4.1.

Table 4.1

FORECAST FUEL PRICES IN CENTS PER LITRE: 1982

| Components of the Transportation System | Fuel | Forecast Prices |
|---|---|---|
| Automobiles, Trucks, Transit & Bus | gasoline | 44.7¢ - 45.5¢ |
| | diesel | 43.2¢ - 44.0¢ |
| Air | gasoline | 43.5¢ - 44.2¢ |
| | turbo | 35.4¢ - 36.1¢ |
| Marine | diesel | 31.2¢ - 31.9¢ |
| | bunker | 23.4¢ - 24.1¢ |
| Rail | diesel | 29.1¢ - 29.7¢ |

Table 4.2

FORECAST FUEL PRICE INCREASES: 1982 - 1990

| Components of the Transportation System | Fuel | % Increase in Prices | |
|---|---|---|---|
| | | "Pessimistic" | "Optimistic" |
| Automobiles, Trucks, Transit & Bus | gasoline | 159% | 110% |
| | diesel | 167% | 115% |
| Air | gasoline | 155% | 110% |
| | turbo | 184% | 121% |
| Marine | diesel | 184% | 121% |
| | bunker | 204% | 129% |
| Rail | diesel | 184% | 121% |

Source: (of both Tables): Transport Canada [24 ]

To put these 1982 prices in perspective, consider that between 1971 and 1982 the price of rail diesel has increased from about 3.3¢ per litre to about 29.4¢ - an increase of almost 800%. Aviation turbo has increased by almost the same amount - from about 4.1¢ to 35.8¢; and marine oil (bunker oil) has increased from about 2.0¢ to 23.8¢ - an increase of over 1000%. Of course, the real fuel price increases - that is, the nominal price discounted by inflation - are more relevant in considering the effect of prices on consumers' or producers' decisions. The magnitude of these real increases has not been nearly as large as the above figures would suggest. In fact, some commentators have noted that between 1971 and (about) 1977 the real price of some fuels - particularly gasoline used by automobiles - hardly increased at all.

The current international situation (OPEC, etc.) and the possibility of the federal and provincial governments modifying their oil pricing policies makes forecasting difficult. With these reservations, then, the forecast fuel prices shown in Table 4.2 are from the same study which produced the figures shown in Table 4.1. Two scenarios were adopted: the "pessimistic" case, which incorporated the assumptions of the National Energy Program and the Alberta Agreement; and, an "optimistic"

case, which assumed a slower growth in international crude oil prices (8% a year in current dollars).

As can be seen, over the next eight years, the price of all transportation fuels is expected to at least double and, under the pessimistic scenario, they may be 2.5 to 3.0 times as high (150% - 200% higher) than current prices.

To summarize, it is clear that government policies are instrumental in the determination of transportation fuel prices. Currently, domestic crude oil prices stand at about 70% to 72% of international prices and the "blended" price stands at about 80% to 83%. (This is in the winter of 1982/83, crude oil delivered to central Canada in comparison to international prices delivered to Montreal, and does not take into account the recent drop in either the posted or spot international prices.) Table 4.3 shows the effect of various government taxes and charges on the fuel costs for gasoline-powered (regular, leaded) road vehicles as of March 1983 (excluding those for which the excise tax is refundable). The Petroleum Resources Communication Foundation in Calgary (which developed these figures) calculates that, on average, taxes, royalties, and other government charges account for 64.2% of the pump price.

Table 4.3

PUMP PRICES (REGULAR, LEADED GASOLINE): MARCH 1983

- cents per litre -

| | B.C. | Alta. | Sask. | Man. | Ont. | Que. | N.B. | N.S. | P.E.I. | Nfld. |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Pump Price | 47.1 | 34.4 | 38.0 | 44.1 | 46.2 | 53.1 | 44.9 | 46.5 | 49.4 | 49.4 |
| Provincial Sales Tax | 7.4 | 0.0 | 0.0 | 6.4 | 7.5 | 14.2 | 6.2 | 8.4 | 9.5 | 9.2 |
| Federal Charges* | 14.4 | 14.4 | 14.4 | 14.4 | 14.4 | 14.4 | 7.5** | 7.5** | 7.5** | 7.5** |
| Royalties & Taxes Paid to Alta. | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 | 15.3# | 15.3# | 15.3# | 15.3# |
| Crude Oil Costs | 5.5 | 5.0 | 5.2 | 5.3 | 5.7 | 5.8 | 3.0## | 3.0## | 3.0## | 3.0## |
| Dealer Margin | 3.6 | 2.4 | 3.4 | 2.6 | 2.4 | 2.6 | 3.6 | 3.9 | 4.2 | 4.7 |
| Oil Company Share | 8.3 | 7.7 | 7.1 | 7.5 | 8.3 | 8.2 | 9.3 | 8.4 | 9.9 | 9.7 |
| Govt's Percentage (both prov. and fed.) | 63.1% | 59.6% | 58.7% | 65.1% | 64.5% | 68.7% | 64.6% | 67.1% | 65.4% | 64.8% |

* Federal Sales Tax, Federal Excise Tax, Petroleum Compensation Charge, Cdn. Ownership Charge and oil company direct cos associated with federal taxes and charges.
** Federal charges less the PGRT & Income Tax.
# Paid to foreign governments for imported crude net of Canadian Government compensation.
## Other related costs for imported crude (i.e., ocean freight).

Source: Petroleum Resources Communication Foundation.

## 4.4 Policies Affecting Vehicle Prices

There are a variety of government policies affecting vehicle prices. These are summarized on Table 4.4; although, only the main details have been shown.[5]

In terms of the potential impact these policies may have on transportation energy efficiency, there are two main points to note. First, since most new vehicles tend to be more fuel efficient than old vehicles, those policies which either work to reduce the price of new equipment or work to encourage operators to invest in new equipment can be seen to have a positive impact on efficiency. There are some obvious qualifications to this statement: it is not true that all new vehicles are necessarily more fuel efficient than all old vehicles (for example, while new aircraft are more fuel efficient than comparable types of aircraft they replace, they still may be less efficient than a loaded Boeing 747); and, the fact that a new vehicle is potentially more fuel efficient than an old vehicle does not guarantee that it will be used more efficiently (for example, a new truck with a poorly trained or poorly motivated driver will use more fuel than an old truck with a skillful driver).

Table 4.4

## POLICIES AFFECTING VEHICLE (& RELATED EQUIPMENT) PRICES

| Policies | Automobile | Trucks | Transit Veh., Buses | Aircraft | Ships | Rail Equip. |
|---|---|---|---|---|---|---|
| Federal | | | | | | |
| 1. Sales Taxes | 9% reduced from 12% in 1978 as a stimulative measure | | | | | |
| 2. Sales Tax Exemptions | | most larger trucks & equip. | most vehicles | most equip. | most equip. | most equip. |
| 3. Special Sales Tax Exemptions | there are a wide variety of items which qualify as "energy conservation equipment" which are exempt; few are relevant here. | | | | | |
| 4. Excise Tax | large cars | | | | | |
| 5. Customs Duties | there are special rules & agreements relating to imports by manufacturers | | | most major equipment is exempt from duty; some exceptions where equipment is manufactured in Canada | | |
| 6. Investment Tax Credit | | most transportation equipment is eligible for 7% credit; the exceptions are small trucks, trucks used locally, small buses | | | | |
| 7. Capital Cost Allowance | 30% for automobiles used commercially 40% for taxis | 30% | 30% | 25% | 15% special 33-1/3% for new Cdn. vessels | 7% (cars) 10% locomotives plus special rates on top |
| 8. Grants | $400 & $600 grants for conversion to propane or CNG | | | | | |
| 9. Subsidies, Other Assistance | a wide variety of programs, tax measures, etc. for vehicle manufacturers | | | | | |
| Provincial | | | | | | |
| 10. Sales Tax | provincial tax rates vary from 0% to 11% | | | | | |
| 11. Sales Tax Exemptions | a few (e.g. propane cars in some prov.) | some provinces exempt energy conservation equip. | | most provinces exempt commercial vehicles, etc. | | some |
| 12. Registration Taxes | various registration & related fees | | | | | |
| 13. Grants, Subsidies Assistance | various programs for transportation operators & vehicle manufacturers | | | | | |

The second point to note is that where these policies encourage more efficiently-sized vehicles or vehicles with equipment that adds to efficiency, these policies can be seen to have a positive impact on transportation energy efficiency. (The converse of both of these points, in terms of negative impacts, is obvious.)

At the federal level, it can be seen that there are many measures which tend to make vehicle prices (or the cost of purchasing vehicles) relatively attractive. (That is, "attractive" in the sense that prices or costs would be higher if some of these measures did not exist.) Most of the large commercial vehicles are exempt from the sales tax (in terms of trucks, the exemption only applies to freight-type vehicles over 7,250 kilograms). There is no excise tax (excise taxes usually only apply to consumer goods, so this is really a non-issue). There are few customs duties (there are some minor ones being overlooked here, and there is one qualification concerning the marine industry). There is an investment tax credit of 7% for most of the larger commercial vehicles (there are some qualifications). Finally, all of these vehicles can be written off against income (for commercial operations) at relatively attractive rates (there is some qualification to this).

In addition to the effect these policies have on the purchase of new vehicles, there are four points to note about their potential effect on the purchase of more efficiently-sized or more efficiently-equipped vehicles. First, and most obviously, the exemption from sales tax for energy-conservation equipment would appear to be the most important policy affecting the choice of energy-efficient vehicles. However, the actual effect of this exemption is minimal as there is only one known instance of where it applies to transportation equipment: aerodynamic-drag-reducing devices for trucks. In addition, of course, this special exemption is not relevant for most of the larger commercial vehicles as they are exempt from sales tax in any case. Further, considering trucks specifically, while parts under $2,000 are not exempt from the sales tax, a new vehicle which had some special equipment attached at the time of sale is exempt; therefore, anyone purchasing a truck with "energy-efficient options" does not pay the tax. The only situation in which the rather limited application of this special exemption would be critical would be where a truck owner wanted to modify existing vehicles (for example, adding radial-ply tires, a fan clutch, or something else which would improve energy efficiency but which cost less than $2,000).

Second, the general effect of a flat percentage sales tax on automobiles means that smaller cars, which generally cost less than larger cars, pay less tax. Third, the excise tax on larger cars (roughly over 1,800 kilograms) affects the relative prices of large cars in comparison to small cars. (This is not that significant as most automobiles weigh less than this.) Fourth, the grants available from the Department of Energy, Mines and Resources for converting road motor vehicles to propane or compressed natural gas have an impact on the incentive to switch from conventional pertroleum-derived fuels. (This is largely a policy affecting substitution; as the discussion in previous Chapters noted, there are difficulties in making efficiency comparisons between two fuel types.)

There are not as many areas where provincial government policies affect vehicle prices. The most important measure is the provincial sales tax which varies from no tax in Alberta and the two territories to 5% - 8% in most other provinces to a high of 10% - 11% in some of the Atlantic provinces. There are a series of exemptions from these sales taxes. With respect to automobiles, the most important is the exemption for new vehicles using propane in Ontario (some other provinces may have also done this or may be considering

a similar exemption for propane or compressed natural gas automobiles). There are also one or two instances of where a province has removed the sales tax on automobiles for short periods of time to stimulate sales.

There are no general exemptions from provincial sales taxes for trucks. However, it should be noted that for the larger commercial vehicles there is an interprovincial sales tax agreement which prorates taxes among provinces on the basis of the proportion of travel in each province (British Columbia and Newfoundland, which do not belong to the agreement, compute the tax on a similar basis). Second, there are a wide range of provincial exemptions (in most, not all provinces) for energy-conservation goods. As with comparable federal exemptions for this type of equipment, there appear to be only one or two instances of where the equipment listed as energy-conservation goods includes such items as wind deflectors for trucks. Most of this exemption applies to thermal insulation material.

With respect to aircraft, most provinces exempt this equipment from sales tax when used in commercial operations. British Columbia, Saskatchewan, and Manitoba tax aircraft

when used entirely within their boundaries. Most marine vessels are exempt from provincial sales tax. The qualifications to this are that the exemption usually only applies to vessels used for commercial purposes; in some provinces (New Brunswick, Prince Edward Island) the exemption only applies to vessels which normally operate in extraterritorial waters; and, in two provinces (Manitoba and Saskatchewan) there is no exemption. Finally, with respect to railway equipment, all rolling stock is taxed (except in New Brunswick); although most provinces prorate this tax on the basis of usage within the province.

The registration taxes levied by the provinces affect the cost of owning road vehicles. While these taxes are considered user charges (Section 4.5), it can be noted here that they are not a significant component of total costs. This observation depends, of course, on how much vehicles are used. However, consider the Canadian Automobile Association's figures for a typical automobile in 1982 where registration fees are shown at less than 1% of total annual costs; or, using Statistics Canada's figures on the "Class I" for-hire motor carriers as a proxy for the entire trucking industry, consider that vehicle license and registration fees for 1980 are shown as being 1.4% of total operating expenses.[6]

In terms of the effect of these provincial policies on either the decision to buy new vehicles or the decision to buy more efficient vehicles, there are a few observations. First, the absence of general exemptions from sales taxes for road and rail vehicles has to be viewed as a disincentive. In particular, the policy has to be compared with the more liberal policies of the federal government and with the more liberal policies of the provincial governments with respect to air and marine vehicles. Further, given that some provinces have occasionally lifted sales taxes on various items to encourage new sales, the policy of not exempting these vehicles must be assumed to be a real and not imagined disincentive. Second, considering road vehicles, the same comments can be made with respect to provincial sales taxes as were made with respect to the federal tax: i) the existence of an exemption for energy-conservation goods is potenially the most significant policy in terms of the interests of this study, but this significance is reduced somewhat by the fact that only one known item qualifies (in one or two provinces); and ii) the general effect of a uniform percentage tax on automobiles means that generally smaller cars are assessed less tax than larger cars.

In terms of the effect of registration taxes on road vehicles, there are two observations. (It has already

been noted that these are relatively minor costs in considering the total cost of purchasing and operating road vehicles.) First, considering automobiles, most provinces and territories set their registration fees on the basis of the tare weight of the vehicle, the wheelbase or the number of cylinders.[7] This tends to impose a higher registration tax on larger vehicles than on smaller ones; however, the differences are so small that it is unlikely that these taxes have any effect on a purchaser's decision. Second, with respect to trucks, all provinces and territories base their registration taxes on a registered-weight basis with the result that larger vehicles are assessed higher taxes than smaller ones. In addition, there is a general tendency to increase the charge per unit of weight for larger vehicles; the most notable "jump" in these unit-weight charges being between the relatively small trucks and the larger (roughly over 7 tonne) trucks. As for the increasing unit charge for the larger trucks, it must also be remembered that the payload to gross weight ratio increases with larger trucks so that it is not clear that the actual registration tax per unit of payload increases for larger vehicles. (There have been no recent studies on this issue, so actual figures are hard to find. However, in some provinces, it is likely that the registration tax per unit weight of payload actually declines for larger trucks.)

Having given a general overview of where federal and provincial policies affect vehicle prices (or the cost of purchasing vehicles), there are some further comments and qualifications to make. These can be made most easily as a series of summary observations on each of the items shown on Table 4.4.

Federal Sales Tax: the primary observation to make is that the general exemption for the larger commercial vehicles would act as an incentive for the purchase of new equipment. This incentive does not exist with respect to automobiles, trucks with a registered gross weight of less than 7,250 kilograms, or small buses or vans used as buses (the cut-off point is 12 passengers). Since most equipment for the air, marine, and rail industries is exempt, the existence of a special exemption and the fact that the list of items included as "energy conservation equipment" does not include many transportation-related items is probably of most significance to road vehicles.

Excise Tax: this is not a significant issue here.

Customs Duties: the only known instance of where the application of customs duties might become an issue in considering transportation energy efficiency concerns the marine industry. According to industry sources, there is a duty which applies to marine engines if comparable engines

are manufactured in Canada. Because some of the smaller engines are built in Canada, because there is some possibility for two small engines in a ship being more efficient than one large engine, and because these industry sources perceived a quality difference between domestic versus foreign engines, the view was expressed that the application of this customs duty might discourage a ship owner from ordering a ship with two engines. (Two engines rather than one, permit the operator at slow or maneuvering speeds to shut one engine down and run the other at a higher level of mechanical efficiency.) The potential for the occurrence of such a situation has not been determined.

Investment Tax Credits: the primary observation to make is that the existence of the 7% credit acts as an incentive for firms to invest in new vehicles. This incentive does not exist with respect to investments in automobiles, trucks or buses used in local situations, small trucks (roughly, less than 12 tonnes), small buses (less than 20 passengers), or school buses. The secondary observation to make is that some industry sources felt that there could be more of an incentive if (i) there were some means of making the credit available to unprofitable firms (obviously the credit only applies when a firm pays taxes), (ii) there were an allowance to carrying the credit forward more than five years, and (iii) possibly there were some

other approach adopted in instances of where vehicles were leased (although the details of this have not been determined, there are apparently some more liberal mechanisms which could be used, in terms of who can claim the credit, in leasing arrangements). There is one further observation on the 7% credit, which was specifically introduced in 1977 as an incentive for investment in new productive facilities. This credit has to be judged in comparison to the other tax credits introduced which can be as high as 50% for resource-based industries. (It is not known if there are any areas where investments in "certified property" yet qualify for this.)

Capital Cost Allowance: the first observation on capital cost allowance (CCA) is that the budget of November 12, 1981, cut the applicable CCA in half for the year in which an asset was acquired. Without debating the merits of this change, it would have to be assumed that this reduces the incentive (ability) to purchase new equipment. The second observation is that the accelerated or increased CCA available for some investments in the marine and rail industries (and for taxicabs) would generally encourage investment in new vehicles (and, in the case of the railways, other assets). These accelerated rates include: i) a 33-1/3% straight-line rate for new marine vessels constructed and registered in Canada (the normal rate is 15% on a declining balance); ii) a variety of special rates for rail equipment

which are in addition to the normal rates (some of these are only available to non-railway owners - for example, a shipper purchasing its own cars); and iii) the special 40% rate for taxis (the normal rate for automobiles is 30%). The final observation on CCAs is that the general level of these allowances has to be judged in comparison to the very high rates available to some other sectors in some situations. For example, there is a 50% write-off allowed for investments in various equipment used for generating electricity, heat production, active solar heating, etc. The objectives of the federal government in establishing these rates ("Class 34") were to encourage companies to conserve energy.

Grants, Subsidies, and Other Assistance: the grant available for converting road vehicles to propane or compressed natural gas is an incentive to switch from conventional fuels. There are other grants, scientific research deductions and allowances, investment tax credits for scientific research, and so on that may have some importance for some transportation firms or vehicle manufacturers in particular situations.

Provincial Sales Tax: in those provinces which levy sales taxes, the existence of such a tax would act as a disincentive for the purchase of road and rail vehicles.

As with the federal exemption for energy-conservation goods, the provincial exemptions are an incentive although their limited application reduces the significance.

Provincial Registration Taxes: the general low level of these taxes does not make them particularly significant in terms of the decision to purchase new equipment. There may be some exceptions to this in the case of some of the larger trucks used in provinces with fairly high rates. For example, using Trimac's 1982 costing data as a guide,[8] annual licence fees in Manitoba for a tractor-trailer registered at 56,500 kilograms are shown at $3,531, or about 2% of the total costs of operating such a vehicle (hauling dry bulk freight and operating 160,000 kilometres annually).

Provincial Grants, Subsidies, and Other Assistance: there are a wide variety of other areas where provincial governments assist transport operators or vehicle manufacturers. In particular, most of the decisions made by urban transit operators and some of the provincially-owned operating entities would involve some government consultation.

## 4.5 Policies Affecting Infrastructure Prices

Most of the taxes or fees regarded as infrastructure prices

for road vehicles have been considered in the previous two sections. This leaves only a few issues here.

Considering first road vehicles and urban areas, there are a series of levies or measures which may be regarded as related to user charges: cartage fees, parking charges, special taxes or regulations affecting parking fees, and so on. Except for one aspect of these urban infrastructure prices, none of these are particularly significant in terms of this study's interest. The exception is any measure which affects parking charges. In actual fact, only those charges for publically-provided spaces can be considered as infrastructure prices in the way infrastructure is being considered here. However, this treatment can be conveniently broadened to consider all measures affecting all parking charges.

It may be noted that any policy which results in a change to parking fees will affect the demand for automobile travel: it is probably true that there would have to be a significant increase before any change could be detected. While a reduction in the demand for automobile travel would presumably result in an increased demand for transit (or ride-sharing), and while these changes might affect the total energy used by the transportation system, this is not the issue in considering transportation energy efficiency.

Rather, the real issue in terms of efficiency changes is the effect this reduction in the demand for automobile travel would have on the flow quality of the remaining vehicles using urban roads. All other things equal, the effect of a policy which increased parking fees will be to reduce the number of vehicles on the road, to improve the flow quality of the remaining vehicles, and to improve the energy efficiency of these remaining vehicles by reducing total resistance (in particular, acceleration resistance) and more importantly by raising the average level of mechanical efficiency. (This assumes there is no change in average operating speed.)

While parking charges are properly an infrastructure price issue, it is so similar to some of the operational issues considered in Chapter 7 that it will prove to be more convenient to consider it again with these other policy areas. In terms of describing actual local government policies, no national source of information is available.

Registration taxes for road vehicles have already been considered. The only further point to note here, with respect to large trucks, is that while the policy of charging higher fees for larger trucks - whether or not this is on an increasing or relatively flat per unit weight basis - is in accord with accepted "road pricing" principles, it is in conflict with a policy goal of encouraging transportation energy efficiency. That is,

since larger trucks are inherently more fuel efficient than smaller trucks (primarily because of the increasing payload to gross weight ratio) any policy which favored the use of larger trucks would be an incentive for improving energy efficiency.

There are some other policy issues in considering registration fees for road vehicles. However, none of these are particularly significant here. The small differential in registration fees for large automobiles in comparison to small ones may have a minor effect on the choices made by some consumers; the special registration fees for some for-hire vehicles are generally too low in most provinces and territories to make much of a difference; and the wide assortment of other fees (drivers' licences, trip permits for trucks, etc.) can be safely ignored.

As for the air industry, there are a wide range of taxes on ticket prices, fuel fees, rental fees, landing fees, and various other airport fees which are considered user charges. The only one of these having any potential to affect transportation energy efficiency is the landing fees. While this is not considered a major issue, it may be noted in passing that fees which assess higher unit weight charges for larger planes are probably acceptable from an airport costing perspective but cannot be

considered an incentive for energy efficiency. The current charges at the larger airports in Canada increase from $1.34 kilogram for aircraft of less than 21,000 kilograms up to $2.00 per kilogram for aircraft over 45,000 kilograms.[9] However, as no evidence could be found to suggest that the structure of these fees has ever influenced a major carrier's decision on the type of equipment to be used, it has to be assumed that this is a non-issue for this study.

For the marine component of the transportation system, infrastructure charges include various harbour dues, docking and berthage fees, the various tolls for use of locks and canals, etc. The only one of these which is important here is the tolls levied on ships using the St. Lawrence Seaway. These charges consist of a cargo toll (per tonne, varying according to the type of cargo) and a vessel charge. These vessel charges used to be based on the unit weight of the ship; however, starting in 1982 these charges have been increased and are now fixed independent of vessel size. By 1983, the total lockage charges for the eight locks on the Montreal-Lake Ontario and Welland Canal will be $2,000 for a loaded vessel irrespective of size. This type of charge, unlike truck registration fees or airport landing fees, has to be seen as an incentive for using larger, more energy efficient ships. (All of these types

of charges for any component of the transportation system can only act as an incentive for greater fuel efficiency if the necessary loads and service factors are offered.)

The final subject to consider on infrastructure prices is the relationship between the total costs incurred by government in providing infrastructure and the total revenue collected from the various user fees. This can be a controversial subject: some of the controversy results from measurement (data) problems and some from methodological considerations. There is no need to consider any of these debates here. Rather, the main interest, aside from briefly describing the current policies, is knowing where the cost/revenue relationships of providing infrastructure may have an effect on energy efficiency.

Broadly, there are two issues in considering the relationship between the cost of providing infrastructure versus the revenues derived from users and the subject of transportation energy efficiency. First, for any component of the transportation system where user charges are set below costs, there will be a greater demand for the use of infrastructure than would be the case where charges were set high enough to recover costs. This effect on the demand for the use of infrastructure may not be large (that is, within the relative range of "low" or "high"

infrastructure charges). Furthermore, while this higher or lower demand for the use of infrastructure has an effect on the total demand for transportation energy, the interest here would be limited to only those cases where there was an effect on energy efficiency. In all likelihood, this only occurs where the higher or lower demand for the use of infrastructure affects the flow quality of vehicles. Without defining "flow quality" in precise details here, this may be commonly understood as "congestion effects".

A second point is related to the first. Considering all components of the transportation system together, the relative level of infrastructure costs and revenues for one component in comparison to another will affect the relative demand for services of the various components. For example, if air infrastructure charges were set at 10% of total air infrastructure costs and rail infrastructure charges (borne by the railways) recover 100% of costs, there would be a relatively greater demand for air travel than for rail travel. Again, within the relevant range of infrastructure prices, this effect on the relative demands for service may not be large; and, again, the interest here is only in changes to energy efficiency and not total energy use. This likely occurs in only those instances where there is an effect on flow quality (the "congestion effect").

Several recent studies provide information on this subject. The Canadian Transport Commission,[10] using 1975 data, notes the following relationships between infrastructure costs of all three levels of government and all user charges: road users as a group pay for about three-fifths of total road infrastructure costs; air operations pay for under two-fifths of their costs; marine operations pay for less than one-fifth; and railways pay none of their costs. (Railways, of course, own and pay for their own infrastructure. However, the study considers such government payments as the subsidies for uneconomic passenger services or branch lines as a part of government transport costs with no offsetting user fees.) To show the importance of "unrecovered" government costs, the study compares them to the total costs of each component. ("Total costs" are the costs incurred by carriers or automobile owners plus the costs paid for by government.) Unrecovered costs at 6% for road users were the lowest, followed by rail at 10%, air at 14%, and marine at 20%.

A more recent study by Transport Canada[11] uses three different methods to calculate the proportion of infrastructure costs recovered by different components of the transportation system: a "cash flow analysis" (that is, a comparison of annual cash expenditures with annual revenues); a "book value analysis" (that is, capital costs are allocated over

the economic life of the asset); and, an "inflation-adjusted analysis" (that is, a book value analysis with the effects of inflation removed). Further, government revenues from user charges are shown two ways: "gross", or all taxes collected; and, "net", or only those taxes collected by the particular level of government which provides infrastructure. The results of this analysis, shown as "government revenues as a percent of costs", for 1979, are:

| | Cash Flow | | Book Value | | Inflation-Adjusted | |
|---|---|---|---|---|---|---|
| | gross | net | gross | net | gross | net |
| air | 63% | 52% | 46% | 38% | 43% | 36% |
| marine | 39% | 39% | 28% | 28% | 21% | 21% |
| road | 62% | 54% | 54% | 47% | 45% | 39% |

Rail cannot be directly compared with these figures; however, if costs are calculated as total infrastructure and vehicle costs, and revenues are calculated as government (user charges) and carrier revenues, comparisons can be made. On this basis, and for here focusing on the inflation-adjusted figures, the road component had a revenue/cost ratio of 90% in 1979, followed by air and rail at 86%, and marine at 78%.

Clearly, there are different ways of looking at (and measuring the importance of) the issue of indirect (and, in the case of the total revenue/cost ratios, "direct") subsidies.

However, all studies (and all measurements) tend to support the primary observation that individual components of the transportation system fail to pay their full costs. While there have been some studies[12] which suggest there are efficiency losses resulting from this situation (which is largely controlled by government policy), these losses are not the more narrowly defined transportation energy efficiency. That is, the efficiency losses at issue in these studies relate to the misallocation of resources which may occur if transportation demand is greater or less than it would otherwise be when prices are set at less than the cost of service. (In this study, it is the energy used to effect a transportation service for a given demand which is at issue.)

## 4.6 Policies Affecting Service Prices

Components of the transportation system which are subject to government rate-regulatory policies include the following: i) within the automobile component, most taxi operations are regulated at the local level (although in some provinces, provincial regulatory boards are also involved); ii) within the trucking component, five provinces regulate some (not all) for-hire rates; iii) most intercity bus and urban transit operations are subject to rate regulation (or, direct government rate-setting); iv) airline rates are regulated by the Canadian Transport Commission; and v)

the marine and rail components of the transportation system can be regarded as effectively unregulated (in terms of rates). The last statement ignores certain statutory rail rates (discussed below), certain powers of the Canadian Transport Commission with respect to rail rates (important, but rarely used), certain powers of the Commission with respect to marine rates (very minor), the power of the Canadian Grain Commission to "roll-back", bulk grain rates on the Great Lakes (never been exercised), and the role of some provinces with respect to marine and rail rates falling under their jurisdiction (very often bound up with provincial ownership).

However, to put this subject of rate regulation in perspective, it has to be pointed out that the proportion of total transportation flows subject to rate regulation is very small and that where rate regulation exists it is often fairly permissive. For example, taxis probably only represent 0.2% of all automobiles;[13] the for-hire truck movements subject to rate regulation are probably less than one third of total for-hire operations[14] and, furthermore, the entire for-hire industry only accounts for about 2% of total trucks in Canada; and, the regulation of air, bus, and transit operations affects less than 10% of total passenger-kilometres travelled in Canada.[15] Furthermore, much of the regulation of passenger rates is "passive" (that is, operators apply for the rates they want and usually receive approval).

A consideration of the potential effects of rate regulation on transportation energy efficiency is very similar to the consideration of indirect infrastructure subsidies in the previous section - the major difference is that the scope for these policies to have any significant effect is considerably less. That is, on the one hand there is a possibility that the effect of rate regulation is to distort transportation prices. This may affect the relative demand for service and cause flow quality effects which may have the potential for affecting energy efficiency. On the other hand, and notwithstanding the existence of some literature which suggests that regulation causes inefficiencies (the broader type), the lack of any empirical evidence which actually can be used to show the effect of rate regulation-demand-flow quality-energy efficiency relationships leaves the consideration of this issue open to speculation.

In terms of the specific types of rate-regulatory policies adopted (and not just the existence or non-existence of regulation), there are several issues. Again, a discussion of these issues is hampered by the lack of empirical evidence. Consider a regulatory agency which adopts a rather rigid policy on rates in comparison to a more liberal agency which permits responsive rate-setting

practices: for example, discount or charter fares for airlines, zones of reasonableness for freight rates, maximum allowed rates with no restrictions on discounting, no lengthy delays in obtaining approval for requested rates, and so forth. There has been a tendency towards flexible rate regulation over the past decade or so - particularly since the passage of the National Transportation Act (1967), the adoption of a policy to allow air carriers to use domestic charter class (and other discount) fares, and some "spill-over" effects from the United States (which has deregulated much of its transportation industry). There is no doubt that flexible rate-setting practices, and the allowance of these practices by regulatory bodies, permits carriers in many instances to achieve higher load factors and thereby reduce the energy consumption per unit of payload. The difficulty, however, in considering this purely in terms of transportation energy efficiency improvements, is that it is not possible to determine how much of this improvement is due to smoothing out the existing peaks and valleys in transportation demand and how much is due to the increased quantity of service demanded.

Finally, one last topic on rate regulation - or, more broadly, government policies affecting transportation rates - is the existence of direct subsidies and statutory rates. The Canadian Transport Commission's latest review[16]

shows that in 1979 the federal government paid out $624 million in direct subsidies to carriers: 69% to the railways (mainly for VIA Rail and other passenger services, and uneconomic branch lines); 23% to marine carriers (mainly under the Maritimes Freight Rates Act); 7% to trucking operations (the Atlantic Region Freight Assistance Act); and a little less than 4% to air carriers. In addition, the federal government spent $82 million on the purchase of grain cars and the rehabilitation of prairie branch lines; various provincial governments subsidized other transportation services (British Columbia ferries, Ontario's rail and bus commuter operations, and so forth); all three levels of government subsidize from time to time local transit operations; and, rail grain rates are held to a level set by statute. (This last policy is currently being revised.)

As with the more direct government regulation of transportation rates, these subsidies and/or statutory rates affect transportation prices and the relative demand for service. This, no doubt, has some effect on the total energy used by the transportation system. For example, it may well be that without the statutory grain rates more grain would move by trucks and total energy consumption would increase (although, when the Hall Commission[17] in the mid 1970s examined this, it

did not appear to be a very significant issue); or, it may be that the existence of various subsidies in the Atlantic region (marine, rail, truck) encourages more demand for transportation and, hence, more energy consumption that would otherwise exist. However, there is no direct empirical evidence to suggest that the existence of these subsidies and statutory rates leads to flow quality effects on individual components of the transportation system.

The statutory grain rates (the "Crow" rates) have a more important effect on transportation energy efficiency. Specifically, and as reported in numerous studies, the effect of maintaining rates below their compensatory level (that is, the level at which rates cover "out-of-pocket" costs) - on traffic which accounts for over 20% of total rail tonne-kilometres (CN and CP) - has been to reduce the railway's financial ability to invest in the type of equipment (locomotives, cars, tracks, etc.) necessary to improve energy efficiency. While this is a controversial subject, while there are policy objectives other than energy efficiency which have to be considered, and while the negative effect of the Crow rates has been off-set in part by various subsidies and other forms of assistance to the railways, there can be little doubt about the veracity of this statement.[18]

## 4.7 Summary

Government policies have a large effect on input prices and, to a lesser extent, service prices of the transportation system. These prices can affect transportation energy efficiency. The important areas where these effects occur are as follows:

Fuel Prices: federal and, to a lesser extent, provincial policies have a very pronounced effect on fuel prices. This, in turn, has the most widespread effect on transportation energy efficiency as producers or consumers are either encouraged or discouraged from making energy-efficient choices. Policies affecting fuel prices affect all components of the transportation system; and, all components of the system have a large incentive to react to these price changes as fuel costs represent a significant proportion of total running costs.

In terms of assessing the impact of these policies, the two points to note are that (i) the general effect of government policy has been to keep the rate at which Canadian energy prices rise below world levels, and (ii) the primary tool used to measure the effect of price changes on demand ("elasticities") is not sufficient

by itself to address the question of whether or not these lower energy prices have retarded the rate at which the transportation system has adopted more energy efficient equipment or procedures.

Vehicle (& Related Equipment) Prices: there are a wide variety of government policies (particularly federal) which affect vehicle and equipment prices (particularly the larger commercial equipment prices). Many of the federal policies have a positive effect on the attractiveness of purchasing or investing in new equipment (new vehicles or equipment will generally have a positive effect on energy efficiency). However, this "attractiveness" has to be judged against the even more attractive policies used to encourage investments in other areas of the economy. There are many other policies that reduce the incentive to purchase new equipment: these are most pronounced with respect to the smaller, non-commercial vehicles (at the federal level) and with respect to provincial sales taxes (in those provinces which levy them, there are not as many exemptions as there are at the federal level). Aside from the effect of these policies on the decision to purchase new equipment, there are one or two instances of where these policies may encourage the purchase of more efficient equipment (and, in some cases, equipment which substitutes more plentiful energy sources).

There is no empirical evidence as to the specific effect of these policies on the transportation system.

Infrastructure Prices (Structure): there appear to be only a few instances of where the policies which affect the structure of infrastructure prices have either a significant positive or negative impact on transportation energy efficiency.

Infrastructure Prices (Relative Level of Cost Recovery): Rate Regulation; Transportation Subsidies: for a variety of reasons, government policies have led to a situation where: (i) transportation users do not pay for all of the costs of government-supplied infrastructure; (ii) the relative level of under-recovery is different for different components of the transportation system; (iii) some transportation rates are regulated; and (iv) there are a variety of government subsidies paid to the transportation system. All of these policies affect transportation prices and the relative demand for service. This may affect total energy consumption and potentially there may be a few instances of where the resulting "distorted" demand for service affects transportation flows to such an extent that there is some effect on energy efficiency.

The assessment of this potential is hampered by the absence of any empirical evidence.

Statutory Grain Rates: although this policy is now been revised, the existence of the Crow rates has had an effect on the railways' financial ability to invest in new equipment. This has been partly off-set by government assistance to the railways.

## Notes to Chapter 4

1. Two recent reports debate the issue of which taxes should be considered as user charges, and different conclusions are reached: P. M. Bunting [3], Transport Canada [26].

2. The information on fuel taxes has been developed from a study by Transport Canada [24], a study by Thorne Stevenson & Kellogg [94], from information supplied by E M & R, and from discussions with some of the provinces.

3. The information was developed by E M & R.

4. Transport Canada [24].

5. Most of the information shown has been developed from a report by Thorne Stevenson & Kellogg [94].

6. Statistics Canada [16]. These figures may be slightly misleading in that they cannot account for owner-operators who pay for their own registrations and in that they include various "for-hire"fees as well as registration taxes.

7. For 1981, Statistics Canada [15] shows that seven jurisdictions based their registration taxes on curb weight, three on wheelbase, one on the number of cylinders, and one on a fixed rate for any car.

8. Transport Canada [95].

9. Transport Canada [25].

10. Canadian Transport Commission [5].

11. Transport Canada [26].

12. See, for example, T. H. Oum [75].

13. There are no accurate figures on this; however, extrapolating the data from a study by B. M. Papillon [77] it is possible to estimate that there are 25,000 taxis in Canada.

14. F. P. Nix and A. M. Clayton [72].

15. According to D. J. Reynolds' figures [87], transit, bus, and air passenger-kilometres totalled 34 billion in 1980 compared to a total of 345 billion.

16. Canadian Transport Commission [5].

17. The Commission on Grain Handling and Transportation.

18. See, for example, the statement in Transport Canada's report on regulation [27]:"they [compensatory grain rates] would enhance the attractiveness of the railway business generally and increase the funds available for investment". (p.35)

## Chapter 5: Infrastructure Policies

### 5.1 Purpose of Chapter

Transport infrastructure is comprised of all those physical facilities on which, over which, or through which vehicles operate. As well as the "travelled-way", it includes the physical aspects of traffic control systems (for example, traffic lights) and facilities necessary to handle or accommodate flow (for example, airport terminal buildings).

Governments are directly involved in the provision and maintenance of much of the infrastructure required for road, air and marine operations. Through subsidy and taxation programs, the federal government is also indirectly involved in the provision and maintenance of portions of Canada's rail infrastructure.

Certain of the characteristics of infrastructure are crucial determinants of transportation energy efficiency. To this effect, they "envelope" the realm of operational possibilities for much of the transport system. Thus, for example, network configuration impacts route

circuity in road transport; lane widths and vertical clearances limit the width and height of trucks; lock dimensions limit vessel size on the Great Lakes; the number of lanes on a freeway limits route capacity, and, thus, for a given volume of traffic, impacts flow quality. Many of these aspects of infrastructure must, of course, be categorized as beyond the scope of this study; to this effect, meaningful alterations, for example, to the configuration of a road network, require both large expenditures and long periods of time. Whatever the case, given the relatively mature state of much of Canada's transport infrastructure, the opportunities for meaningful reductions to, say, route circuity, are few and far between, having already been largely exercised.

Nonetheless, governments continue to spend large amounts on transport infrastructure, Much of this expenditure has shifted from the infrastructure development programs of the 1950's and 1960's to rehabilitation, maintenance and the so-called "transport system management" programs of the 1970's and 1980's. Indeed many believe that this new focus will consume the major portion of government transport budgets for many years to come.

The purpose of this Chapter is to examine the nature of government policies which affect infrastructure in a manner which, holding other things constant, affects transportation energy efficiency.

## 5.2 Policies Constraining Vehicle Size and Weight

Certain geometric and structural features of infrastructure impose absolute limits on vehicle size, weight, and/or configuration. These limits are typically established within the context of design standards adopted by government agencies, typically varying as a function of class of the facility. The following observations are relevant to the concerns of this study:

Road Transport: In a practical sense, road geometry standards (policies) do not restrict or limit the size of automobiles. That is to say, the size of the automobiles could, for example, be doubled (or halved) without any important alteration to road geometry. The same cannot be said for trucks (and buses). Infrastructure features do impose practical limits on certain dimensions of these vehicles (and, therefore, vehicle size, payload-handling capabilities, and energy efficiency). Nonetheless, it is of consequence that regulatory restrictions on truck (and bus) dimensions are generally well within the boundaries of infrastructure-related restrictions (except

for vehicle height). Thus, by changes in "rules" as distinct from infrastructure features, substantial increases in truck size of consequence to energy efficiency could be effected. For example, on most major highways, truck widths and lengths could be extended by (say) 10% without altering infrastructure features. This in fact has been happening in recent years, particularly in relaxing "rules" governing total vehicle length, with no attendant adjustments in roadway geometry.

The limits imposed by roadway infrastructure on vehicle weight introduce another dimension over and above the idea of an absolute physical restriction as is associated with geometry. To this effect, "life expectancy" of the infrastructure is the important practical determinant of weight limits. While there are obvious absolute vehicle weight levels that a bridge or a pavement can accommodate, for the most part these are generally well beyond (in some cases, orders of magnitude beyond) the limits established by "rules". If the rules were relaxed by (say) 10%, neither pavements would crumble nor bridges would tumble; however, their life expectancy may change.

Thus, except in isolated cases, roadway infrastructure design standards governing vehicle size and weight are not a limiting factor on transport energy efficiency.

Air Transport: Runway lengths and/or pavement structures in isolated cases, may prohibit the employment of (say) large wide-bodied (energy efficient) aircraft in serving particular markets. However, there is no evidence that such restrictions are of any real consequence to the energy-efficiency issue.

Marine Transport: Infrastructure features on inland waterways, in particular, do impose long-term effects on energy efficiency of marine transport operations. For example, the American Poe Lock at Sault Ste. Marie facilitates use of larger, more energy-efficient vessels on the upper Great Lakes than those that can be used on the lower Great Lakes and the St. Lawrence River. Obviously, however, these government policies which establish such limits on vessel size are of long-duration, and of high cost to alter.

## 5.3 Policies Affecting Routing Efficiency

Network configuration and its implications for "directness-of-routing" (or its inverse "route circuitry") are of obvious consequence to transportation energy efficiency, given that the useful transport work that is being accomplished is movement of payload over the great-circle distance (shortest path) between two points, as distinct from routed distance.

The directness of routing of air and marine vessels is not affected by government infrastructure policies (although it may be impacted by operating policies). Infrastructure-related routing inefficiencies in rail operations are at best only indirectly effected by government, and then typically only on small aspects of the rail system. An example of where government policy might impact routing inefficiencies in rail would be where government prohibits a railway from abandoning a particularly circuitous branch-line.

On the other hand, because of government's direct involvement in the provision of road infrastructure, government policies can effect important infrastructure-derived routing inefficiencies (or efficiencies) on motor vehicle operations. Thus, for example, roadway investment and design policies of the 1950's and 1960's led to dramatic reductions in routing circuity for highway operations. This was done through the superimposition of relatively direct intercity highways on grid-structured networks in rural areas, and the development of radial and circumferential arterial networks in many major urban areas. By the early 1970's much of the highly productive developments of this nature had been completed and there had developed some reluctance on the part of the public (and government) to

continue with any further major road building programs. Thus, particularly in certain urban areas, planned road developments of potential impact to routing efficiency of motor vehicle operations were not implemented, or are being implemented very slowly.

There is no hard evidence suggesting to what extent the policy of non or slow completion of road network modifications directed at relieving routing inefficiencies is impacting transportation energy efficiency of motor vehicle operations. At this stage, one can simply observe that such non-actions probably are having negative impacts, particularly in those major urban areas whose planned road networks were not completed before the end of the road building era. The size of the potential impact of continued non-action, however, is unknown.

## 5.4 Policies Affecting Vehicle Speed and Performance Requirements

The design and provision of infrastructure for motor vehicles incorporates limits on maximum vehicle speed and certain "expectations" relating to propulsion and braking capabilities. For example, the design of a highway references a design speed. Under no circumstances is it considered safe for vehicles to be operated at greater than the design speed. Further, the selection

of highway grade, the design of special roadway features such as acceleration and deceleration lanes, and provisions for passing, presume certain power and braking capabilities for vehicles.

These aspects of roadway infrastructure have varying impacts on the transportation energy efficiency of motor vehicle operations, depending on the setting (rural or urban) and vehicle type (car/light trucks/ buses versus heavy trucks). The following observations are of interest:

Cars, Light Trucks, & Buses: These vehicles are generally grossly over-powered relative to the types of loads experienced by their propulsion systems in normal operations. Thus, energy inefficiencies associated with the general "over-powering" of these vehicles cannot be "blamed" on infrastructure design policies. Consumers choose excess power; the infrastructure does not necessitate it.

Rural highways are designed (and typically regulated) for maximum speeds well beyond the desired speed for fuel economy. In urban areas, on the other hand, infrastructure features (as well as "rules") often

limit speeds to something less the optimal for fuel economy purposes. Thus, infrastructure policies, including those related to traffic control, directed at urban areas to (say) 55-65 kilometres per hour versus 45-50 kilometres per hour could effect improvements in the transportation energy efficiency of these vehicles.

Heavy Trucks: In a practical sense, infrastructure policies relating to vehicle speed and performance capabilities are at best of secondary impact to the energy efficiency of trucking. To this effect, major trucking operations typically restrict maximum speeds to something less than both design speed and speed limit. Further, overall criteria rather than infrastructure-related vehicle performance expectations would be the prime determinants of the choice of power, and in turn the existence of excess power. Generally, existing roadway features would permit the use of substantially less power in trucking operations (and presumably improved overall energy efficiency), but such is rejected for other reasons (such as excessive increases in travel time, and therefore labour costs).

## 5.5 Policies Affecting Flow Quality

For the purpose at hand, "flow quality" is considered to be a measure of the "smoothness" in flow of a traffic

stream. This flow quality is affected by two basic factors: system capacity; and, traffic control measures. In the first case, as the volume in a system of absolute capacity increases, congestion effects are experienced with a consequent increase in travel time, and at high congestion levels, numerous speed changes. In the second case, traffic control measures, even under low flow conditions, can "interrupt" traffic flow, requiring speed changes and/or waiting. Given other things equal, where extensive speed changes and/or idling is experienced by a traffic stream, energy inefficiencies may result.

Clearly, infrastructure characteristics, and related design standards or policies can and do impact flow quality and, therefore, energy efficiency. This is most evident in urban areas where rush-hour travel generally entails significant congestion effects, and traffic control systems regularly interrupt flow. Similarly, operations at major airports during peak hours experience congestion effects which impact energy efficiency. For both major urban roads and major airports, it is to be recognized that the design process envisages certain levels of congestion and traffic interruption and, therefore, energy inefficiencies.

Improving flow quality, particularly for urban road traffic, is generally viewed as an area having substantial potential for improving transportation energy efficiency. The issue is of little (if any) consequence for rural road traffic, given the low volume/capacity ratio generally experienced, and the relatively insignificant amount of infrastrcuture-imposed traffic interruptions (for example, few stop signs on major intercity highways).

## 5.6 Summary

For the most part, infrastructure limits on potential improvements in short-to-medium term transportation energy efficiency are minor. Changes in "rules" and operating procedures within the confines of existing infrastructure could realize much more cost-effective improvements in transportation energy efficiency than could major alterations to infrastructure itself. (These are considered in Chapter 7.)

One exception to this general position involves infrastructure used by autos, light trucks and buses in major urban areas. Improvements to this infrastructure, and most particularly traffic control systems, directed at improving flow quality and/or increasing average operating speed, offers an important opportunity to realize improvements in transportation

energy efficiency. Further, accelerated completion of urban road networks directed at reducing route circuity could produce improvements in energy efficiency for all urban traffic. However, to the extent the implementation of these urban infrastructure improvements entails the expenditure of "new" public money (as opposed to alterations in existing annual budgets), these policies are out of scope to this study.

# Chapter 6 Vehicle Policies

## 6.1 Purpose of Chapter

In this Chapter, government policies affecting vehicles are considered. In addition, and although there is some overlap with infrastructure and operational issues, some background material on fuel-efficiency changes which have occurred or may occur in the future is given. This background material is necessary to put the potential impact of government policies in perspective.

## 6.2 Types of Vehicles

With respect to automobiles and, to a certain extent, light trucks, there are many reports available on vehicles and energy efficiency. One of the more recent comprehensive studies was a 1980 report published by the Mellon Institute in the United States.[1] This is a particularly useful source as the authors relied exclusively on information supplied by North American automobile manufacturers and developed the information into a forecast of what future vehicles would be like considering only the known technology and the future plans of the manufacturers. The forecasts are valid on the assumption that manufacturers can raise the necessary capital to invest in the facilities required

to produce new models; and, the forecasts assume no significant shifts in consumers' tastes for different sized automobiles.

With these factors in mind, then, the study suggests that North American cars will improve (on average) from 8.16 kilometres per litre (km/L) in 1979 to 13.69 km/L by 1985. Furthermore, from 1985 to 1990 there will be an improvement to 16.11 km/L and by the year 2000 the average car will be up to 19.81 km/L. Over the 21 year period, this represents a 143% improvement in the distance one litre of fuel will take the average car; or, stated another way, only 41% as much fuel used to drive a car in 1979 will be required by a car in the year 2000 to travel the same distance.

Light trucks are forecast to undergo somewhat less impressive improvements, moving from an average 6.38 km/L in 1979 to 9.99 km/L by the turn of the century. This is a 57% improvement in the distance a given quantity of fuel will power a light truck.

These are impressive forecasts. The reason for dwelling on them is that the potential impact of government policies has to be weighed against these forecast changes. In particular (and ignoring the question of

whether or not consumers will buy the "average-sized" cars), consider what would happen to total transportation fuel consumption if those future cars and light trucks had been available in 1980. If these vehicles had been available and if operators drove the same distance, total transportation fuel consumption in Canada would drop by one-third. This saving would represent more fuel than the total fuel consumed by all medium and heavy trucks, all aircraft, all ships, and all trains combined!

Considering the larger road vehicle, (medium and heavy trucks, and buses), the future course of technological change is not as evident. However, it is entirely reasonable to assume that many of the technological changes affecting automobiles and light trucks will be accompanied by comparable developments with these larger vehicles. In fact, it may well be that the speed at which new "fuel-efficient" technologies are adopted by commercial fleet operators will be (and has been) faster than in the case of automobiles: "consumers' tastes" are less of a factor.

While the future course of technological change for trucks (and, to some extent, buses) has not been

forecast in as much detail as automobiles, some of the past trends are relevant. Two illustrative examples demonstrate the changes that have occurred. (These are illustrations only and should not be used to infer what happened to the industry on average. Also, the figures reflect both changes to vehicle technology and many operational matters.)

The first illustration is provided by a trucking executive speaking at a conference in Vancouver in January, 1981.[2] This person notes that his company used gasoline-powered equipment in the mid 1950s which averaged about 1.0 km/L with a payload of something under 10 tonnes. By the early 1960s this company had switched to diesels which were averaging about 1.9 km/L with a payload over 21 tonnes; and, by 1981 with even larger and more modern diesels, the company was averaging almost 2.0 km/L with a payload of about 28 to 29 tonnes. In total, the energy consumed per tonne-kilometre had dropped to about one fifth of the energy consumption in the mid 1950s.

The second illustration concerns a recent "Economy Challenge" competition conducted by the Ontario Ministry

of Transportation and Communications. In all, 160 drivers competed on two runs (402 kilometres and 542 kilometres) in various weight classes. The results of these tests show the effect of not only technological change but also of ideal operating conditions and, even more importantly, highly-skilled drivers. The top driver, in the over 54.5 tonne class, averaged about 2.4 km/L. Although the actual payload is not given in the test results, trucks in this weight class would typically haul something in the order of 32 tonnes. To put this in perspective, this top driver, under ideal conditions, used about three quarters of the energy per unit of payload that the trucking company in the previous illustration averaged in 1981. Even more astonishing, this truck used only one-third more energy per tonne-kilometre than the typical figure shown in most studies for Canadian railways.[3] This is "astonishing" in the sense that most studies, which are often subject to some controversy, show railways to be 3 to 4 times as energy efficient as trucks (ignoring service differentials).

Developments with aircraft have been and will continue to be equally as impressive. For example, one recent study[4] shows that between 1970 and 1980, the large Canadian airlines reduced the amount of fuel consumed

per unit of payload by 29%. (Air Canada and CP Air alone improved by 34%.) Much of this improvement was attributed to the introduction of wide-body fuel efficient aircraft. Looking into the future, this same study suggests that the new aircraft - the Boeing 767 and 757 and the A310 and 320 - will reduce fuel costs by a further 25% to 30% over existing wide-body aircraft.

Although the past and future developments within the marine industry are less clear, there are many ideas being discussed by ship builders and ship owners. Some of these ideas include new materials for hull forms (to reduce hull weight), steering nozzles (to improve propulsive efficiency), slow speed large diameter propellers running in a ducted keel, different engines, and even more dramatic changes such as the reintroduction of sails.

Two aspects of the marine industry make a consideration of how government policies affect vessels somewhat different from the other components of the transportation system. First, the limited amount of material available suggests that future improvements in energy efficiency will not be as dramatic for the marine industry as they will be elsewhere.[5] Second, in considering possible

changes to marine vessels, or the rate at which technological developments can be dispersed, the very long life of these assets has to be borne in mind. In particular, fresh water vessels can have useful lives of up to fifty years.

The most dramatic development within the railway industry, the introduction of diesel-electric locomotives, has already occurred. In the twenty-five years since these locomotives were introduced, there has been a five-fold increase in transportation energy efficiency (ignoring any changes in service). Future developments will include gradual improvements to locomotives and cars, and of equal or greater importance, improvements to infrastructure (road beds, tracks, traffic control systems, yards, etc.).[6] One railway executive, speaking in 1981, foresees future improvements in the area of 20% (that is, 20% reduction in fuel consumption for a given amount of work).[7]

## 6.3 Policies Affecting Maximum Vehicle Size and Weight

Large trucks and buses are the only component of the transportation system subject to government regulations on maximum vehicle sizes and weights. (This is independent of policies affecting infrastructure.) Truck dimensions

(height and width) are regulated in consideration of the limitations imposed by infrastructure (underpasses or clearances, lane widths); although, it may be noted that the standard limits are set well within the absolute limits. Special permits are available in situations where trucks exceed the standard limits. Maximum allowable lengths are set in consideration of the safety of handling very long trucks (combinations of truck tractors and trailers), in consideration of the design of infrastructure (turning radii, etc.), in consideration of other vehicles using the roads (for example, automobiles have more difficulty passing longer trucks than shorter ones), and in consideration of load distribution (particularly on bridges).

Chapter 2 provided a brief explanation as to the importance of payload-handling characteristics, in particular, the ratio of payload to gross weight. To put this in perspective, it easily can be shown that a "typical" large truck (payload of 31.8 tonnes) experiences something in the order of three-quarters the resistance per unit of payload as does the "typical" tractor-trailer most common a decade or so ago (payload of 18.1 tonnes).[8]

The actual description of the provincial (and territorial) regulations on vehicle weights and dimensions is complex. It is not simply a case of each jurisdiction specifying one single standard for height, width, length, and weight; rather, there is a whole series of regulations applying to different truck types, different weights allowed for different axle combinations of tractors and trailers, regulations on tire loads, regulations on spring weight restrictions, and a whole set of special permits and special cases.[9]

There are three general observations about these policies. First, and particularly in respect of maximum allowable weights, it is to be recognized that these regulations are set with a large degree of discretion; that is, they are largely a function of what people believe to be "safe" or "acceptable" or a function of desired service lives of infrastructure. Second, the lack of uniformity between Canadian jurisdictions and the lack of uniformity between Canada and the United States imposes some penalties on energy efficiency. (It might be noted, though, that Canadian jurisdictions have made some attempts and are continuing to attempt a greater degree of uniformity.) Third, and of most importance, the current regulations governing vehicle weights and dimensions are much more liberal than those of a decade ago.

## 6.4 Policies Affecting Minimum Vehicle Performance Capabilities

All vehicles are designed with certain minimum performance capabilities and many aspects of infrastructure are designed with these capabilities considered (for example, passing distances on highways, length of runways, etc.). However, this study has uncovered no significant government policies which directly relate to minimum vehicle performance capabilities, and which would have a bearing on transportation energy efficiency.

To expand on this, it is true that various provincial regulations governing road vehicles are somewhat related to minimum performance capabilities. For example, the requirement to have lights and the requirement that the lights be of a certain minimum strength are aspects of performance. However, none of these regulations are important here. (One province, British Columbia, requires that the larger tractor-trailers have gross weight to horsepower ratios of no more than 300:1. It could be argued that such power requirements affected fuel efficiency while these vehicles operated over level terrain; but this seems too insignificant to debate.)

## 6.5 Policies Affecting Fuel Type and Quality

There are several areas where government policies affect fuel type or the quality of fuels. Having noted this, however, it is not clear that any of these issues are of much significance to this study. The reasons for this include the lack of evidence on whether or not fuel quality (within the relevant range) is particularly important in considering energy efficiency, and the previously noted difficulty in making efficiency, comparisons between fuel types. (In particular, it is hard to justify a statement that the use of one fuel results in a less energy efficient system if the cost of that fuel means that less money is spent.)

The most important policies affecting fuel type for all vehicles is, of course, the influence governments have over fuel price. For operators of road vehicles, this influence may affect the choice of gasoline, diesel, propane, and (more in the future) other gases or mixtures of conventional fuels with such substances as alcohol. For the air industry, this may affect the choices between "Jet A" and "Jet B" turbo fuels. For the marine industry, these price differentials affect the choices between the heavy oils, diesel, and even some possible future

consideration of other fuels (coal, etc.). For the railways, the choices are between the conventional diesel fuels, heavier fuel oils, and the gas/oil side-stream from the tar sands plant. Ultimately, the price of railway fuel will affect the decision on rail electrification.

In addition, some policies on vehicle prices, such as grants to convert to propane, affect the decision on fuel type. Various demonstration programs, conversion of government-owned vehicles, government assistance in setting up retail distribution systems for compressed natural gas, and various other programs all have an effect on fuel type.

With respect to fuel quality, the issues are related primarily to the lower quality of some fuels (primarily the middle distilate fuels such as diesel) which result from the lower quality (or heavier) feed stocks being used and the efforts of the refineries to extract more fuels out of this range. The result is that these fuels have lower cetane numbers, there is more clouding and waxing at low temperatures, and sulphur contents and contamination (water and sediments) are rising.

## 6.6 Policies Affecting Fuel Economy

The only government policy directly affecting the fuel economy of vehicles is the federal Corporate Average Fuel Economy (CAFE) guidelines. These apply to both North American and imported automobiles sold in Canada; they are voluntary; and they generally follow the standards established in the United States (without quite as rigid a timetable). The effect of CAFE is to have each manufacturer or importer sell a fleet-averaged car that gets - on a labratory test basis - 33 mpg (11.68 kilometres per litre) by 1985. In addition, there is an act which has not yet been proclaimed which would give the government some further authority to set these fuel consumption standards.

One of the more contentious debates in the literature on transportation energy efficiency is whether or not these guidelines (or, in the U.S., standards) have had any effect. Some, who believe the market price of fuel controls these matters, argue that the government policies are irrelevant. These people like to point to the example of General Motors which began planning its "downsizing" program some three or four years before the policy was introduced; and, they also attach much significance to the fact that in the last few years the new cars which

have been sold exceed (on average) the guidelines. To further substantiate their point, these people also point to the fact that gasoline sales have fallen significantly over the past two years. (Some of this fall, of course, is attributable to the recession, and the increase in urban transit ridership.)

People on the other side of this debate argue that the real price of fuel - that is, the nominal price discounted for inflation - has not risen rapidly enough to induce consumers to make the "right" choices in buying new automobiles. They maintain that the guidelines (standards) were required to force the pace of the automobile manufacturers. As evidence that consumers have not responded well enough to rising fuel prices, these people point to some surveys which suggest that Canadians are actually driving more than they were a few years ago.[10]

It is unfortunate that this debate cannot be resolved here, as it would be of some interest to know whether or not this particular government policy had any effect on transportation energy efficiency. (Aside from policies affecting the price of fuels, this is one of the few government policies which is specifically aimed at doing something about transportation energy efficiency.)

## 6.7 Policies Affecting Vehicle Safety

Vehicle safety is the objective of a number of federal and provincial government acts and regulations promulgated under these acts. Provincial acts (and regulations) specify standards for road vehicles used on the road; federal acts (primarily the Motor Vehicle Safety Act) authorize the setting of safety standards for new road vehicles either manufactured or imported; the federal Aeronautics Act deals with air safety and the Canadian Air Transportation Administration, operating under powers conferred by the Act, has procedures for issuing certificates of airworthiness; the federal Department of Transport (the Ship Safety Branch within the Canadian Marine Transportation Administration of Transport Canada) develops standards for the design and construction of marine vessels; and, under the federal Railway Act, the Canadian Transport Commission is given wide powers in matters of rail safety.

In most cases, these policy areas are of little concern here: first, most of these regulations or standards are so obvious in terms of the safety of vehicles that the "feasiblility of change" criteria adopted in Chapter 1 rules out their importance to this study; and second, particularly for most of the large commercial vehicles (ships, trains, and to a less extent trucks, buses, and

aircraft), safety regulations do not appear to have any material effect on energy efficiency. This second point is based on comments made by industry representatives: their feeling was that most safety regulations (for example, a requirement to use non-flammable partitions on ships) were too insignificant, considering the size of the vehicles, to make any difference in total weight or performance.

Automobiles are the only component of the transportation system where there is some debate as to the effect of safety regulations - at least in terms of the impact on energy efficiency. The concern evident in this debate is where safety standards add to the weight of automobiles and, hence, increase the total resistance to be overcome. Although not uncovered in the literature on this subject, other concerns might include where or if safety standards affected aerodynamic drag (for example, mirrors or other protrusions) and,possibly, mechanical efficiency. Some studies from the United States have suggested that safety standards do indeed add to the weight of automobiles[11]; however, in discussions with the Road and Motor Vehicle Traffic Safety Branch (of Transport Canada), it is apparent that some caution must be used in considering these simple "added weight" approaches to the issue. That is, the evolving nature of automobile design and the incorporation of the safety objectives in these designs makes it difficult

to draw any definitive conclusions on the subject.

## 6.8 Policies Affecting Noise and Emissions

Three components of the transportation system are subject to regulations affecting noise or emission levels which may have a bearing on transportation energy efficiency. (In fact, there are wide areas where noise - such as prohibitions against excessive horn blowing or prohibitions against certain types of mufflers - is regulated, but which are not considered significant here.)

First, automobiles and light trucks (road vehicles under 2,721.6 kilograms) are subject to emission standards on carbon monoxide, hydro-carbons, and nitrogen oxide. The standards are set by Environment Canada and administered by Transport Canada. Although there are some who argue that emission controls have had an effect on fuel economy, there is considerable disagreement on the importance of this issue.[12] Related to this, under the Federal Clean Air Act the amount of lead in gasoline is regulated in Canada. Again, there is some debate over the effect of lead, or more particularly, unleaded fuels on energy efficiency. (In this case, the debate goes beyond the definition of transportation energy efficiency adopted here. Consideration is also given to energy used by

refineries to produce different fuels.) Finally, there are some standards limiting the noise of automobiles; however, no evidence has been uncovered to suggest that these standards affect energy efficiency.

Second, considering the larger road vehicles (particularly trucks), there are fewer standards governing noise and emissions. However, the issue of regulating truck noise has gained some importance lately as the United States is considering adopting more restrictive standards. (Canadian regulations often follow the pattern set in the United States.) While no studies have been located to suggest what the effect of these standards will be on fuel efficiency, it is understood from discussions with the industry that if vehicle manufacturers meet the standards through such devices as engine shields, there could a weight penalty.

The third component of the transportation system where noise regulations may be a factor in considering energy efficiency is the air industry. This is a complex issue and many of the "noise abatement policies" relate to the consideration of policies affecting operations in Chapter 7. In terms of the aircraft themselves (and not operating procedures), all that is known on this subject is that the newest aircraft are considerable quieter (and more fuel efficient) than

earlier ones, and that commencing in 1986 there will be some noise certification requirement. It is not known if any of the efforts to make these new aircraft quieter have involved sacrifices on energy efficiency.

## 6.9 Policies Affecting Vehicle Maintenance

Some aspects of vehicle maintenance are important in considering transportation energy efficiency. For example, for road vehicles, the pressure of tires or the regularity of tune-ups have a considerable effect on fuel consumption. However, for the larger commercial sectors of the transportation system there are no known instances of where government policies could be considered important in considering impacts on energy use. There are obviously some requirements or standards that relate to safety which involve aspects of vehicle maintenance, but it is not feasible to consider any changes to these requirements here. Furthermore, in discussions with industry, it is apparent that the operators themselves are generally aware of the importance of maintenance practices (in terms of energy use). There are also a variety of government and industry publications available which promote these ideas.

The only policy issue which might be of some significance here are those provincial regulations or programs which

relate to road vehicle maintenance - particularly automobiles and the smaller trucks. Most provinces have some form of vehicle inspection program - either regulations specifying some aspects of vehicle conditions, spot examinations, or regulations governing the condition of used vehicles when sold. However, the intent of most of these procedures is to ensure vehicle safety (including emissions) and except where vehicle-safety and vehicle-energy objectives happen to coincide, there is little or no energy-efficiency content to these programs. (Some provinces such as Ontario have done some work in the area of energy efficiency and vehicle inspection programs; and, the Federal Department of Energy Mines and Resources in collaboration with the Canadian Automobile Association has conducted an "Operation Tune-up" program. However, these activities,while important, do not contradict the prime observation made here.)

## 6.10 Policies Affecting Research and Development

One final area where government policies may have an impact on energy efficiency is the amount and extent of government-run or government-assisted research and development. In fact, this subject covers more than just vehicles as it may include infrastructure and operating practices. However, it is convenient to treat the subject of R & D here in one place.

At the federal level, there are a variety of programs, fiscal measures, or groups within various departments which contribute, or are evidence of government policy in this area. For example, there are the various scientific research deductions and allowances, and investment tax credits for scientific research referred to briefly in Chapter 4; there is the Transportation Development Centre in Montreal (an R & D arm of Transport Canada); there is the Office of Energy Research and Development (within the Department of Energy Mines and Resources); there is the National Research Council; and so on.

At the provincial level, there are a large number of R & D programs. Some of these involve the development of new transport technology, some are in the form of assistance to manufacturers, others are more in the line of demonstration projects, and some - although not specifically concerned with vehicle technology - include such things as the development of new traffic control systems for railways or methods of optimizing routings for truck operations.

It is impossible to say just what the impact of these policies are. As a very general comment, the existence of these policies is undoubtedly important to the process

of introducing new technologies to the transportation system which, over time, increase the energy efficiency of the system.

## 6.11 Summary

There are a wide variety of federal and provincial policies which affect the vehicles used by the transportation system. In most cases, however, these policies have a minimal impact on energy efficiency or the evidence on the effects on efficiency is unclear. The important elements of these policies are as folllows:

Maximum Vehicle Size and Weight: the trucking component of the transportation system is the only significant area where government regulations affect maximum vehicle size and weight. The most important points to note about these policies are that there has been a significant increase in the maximums allowed over the past ten to twenty years; that, as with all things, there is room to argue both for and against further increases; and, that the lack of uniformity among the jurisdictions has some detrimental consequences.

There are few empirical studies available on what the effects of past increases in vehicle weight and dimension

regulations have been: for example, decreasing the number of trucks on the road, increasing average payloads, changing fuel consumption, etc. However, to speculate on the importance of this issue, several points have to be borne in mind. First, from Table 2.1, medium and large trucks account for 13.8% of total transportation fuel consumption in Canada; and, second, there would only be a small proportion of these trucks which would ever take advantage of higher maximum allowable weights and dimensions. On this second point, note should be made of one study[13] which surveyed truck trips in the western provinces both before and after the provinces increased maximum allowable weights: the increase, on the primary highways only, was from 36.3 tonnes to 49.9 tonnes (with some qualifications). In the "after" survey, only 11.3% of the surveyed vehicles were registered above the previous maximum limit. The 11.3% of the trucks which took advantage of the higher weight limits appear to have accounted for 72% of all trips surveyed: the report on this survey is unclear on this point. However, and whatever the correct interpretation of the figures in this report, the significant point to note is that after the weight limits were increased, very few of the recorded truck trips were in the highest levels of the new weight limits. Most of the truck trips clustered in 80 to 90 thousand pound (36.3 to 40.8 tonne) band; very few approached the new limit of 110 thousand pounds (49.9 tonne).

This suggests that although weight limits are an important issue for some trucking operations, the total amount of fuel used by this segment of the industry is a relatively small proportion of total truck fuel.

Minimum Vehicle Performance Capabilities; Fuel Quality; Vehicle Safety; and Noise and Emissions: there are government policies affecting all of these aspects of the transportation system, and furthermore,there are some important policy issues in these areas. Nevertheless, there have been no issues uncovered which could be said to be significant in considering transportation energy efficiency. In some cases, the reason for this is the lack of uncontested(or any) evidence.

Fuel Type: government policies, either through their effect on fuel prices or through more direct means (including such areas as "promotion"), have an effect on the types of fuel used by the transportation system. Further, the general point made in the literature on the subject - particularly the future choices which will have to be made - suggests that there is room for clarification of government policy in this area.[14] This subject cannot be treated here: comparisons of the energy efficiency of one fuel type (and associated propulsion system) to another are only one

aspect of the whole issue and pale in comparison to the importance of cost and supply considerations.

Fuel Economy (CAFE): although the debate on whether or not the fuel economy guidelines have had an impact cannot be resolved, it seems reasonable to consider the possible importance of this issue in conjunction with Canada's position in world automobile markets and the policies adopted in the United States. First, it is not realistic to believe that Canadian policies, by themselves, can play the dominant role in "forcing" the pace of technological developments within the automobile industry. Second, and primarily in light of the Mellon Institute study, it does not appear that technological developments - that is, the discovery of and the development of new technology - is the critical issue. Although a long way from being a "street legal" vehicle, the University of Saskatchewan's "TENSOR" car set a record in June 1982 at 460.9 kilometres per litre (1,302.2 mpg). The faculty member overseeing this project suggests that "street legal" cars achieving well over 70 km/L (200 mpg) are quite possible.[15] Third, without debating the issue of the effect of the fuel economy standards in the United States, the important point in considering the potential impact of similar Canadian policies is i) there are American policies, and ii) whether or not these policies have any effect, automobile manufacturers have met the standards. In

other words, whether or not Canada had any policies in this area, it seems there is an opportunity to ride on the "coat tails" of American policy.

Given these three considerations, it would appear that Canadian fuel economy guidelines cannot be the dominant factor affecting improvements in automobile fuel efficiency. They may, however, play a useful "information" role for consumers making new automobile purchases (that is, by providing comparative figures).

Vehicle Maintenance: in terms of automobiles and light trucks (and possibly some of the larger road vehicles), the current provincial policies on vehicle maintenance would appear to have little impact on energy efficiency in the sense that these policies are aimed primarily at the issue of vehicle safety and not vehicle energy efficiency. However, considering that various studies have shown improved maintenance procedures for the average car may have significant effects on fuel efficiency - there is considerable debate on the precise amount[16] - this would seem to be one of those areas where "non-action" can be considered a policy. There is a qualification to this that cannot be resolved here. Specifically (and based primarily on discussions with Ontario's Ministry of Transportation and Communications), it is not known how effective or how feasible it would be to alter the existing vehicle inspection programs.

Research and Development: while the comment that government policies on R & D are "probably important" is rather hollow, there is no known way of empirically measuring the impact of these policies in the specific case of vehicle developments and improvements to energy efficiency.

## Notes to Chapter 6

1. R. H. Shackson and H. J. Leach [88].

2. G. Reimer [83].

3. The winner of Ontario's "Trucksave Economy Challenge" averaged about 6.9 mpg with an assumed load of about 70,000 lbs. (The release from the Ontario Ministry of Transportation and Communications shows that this driver averaged over 450 gross ton-miles per gallon.) With 166,500 BTU per gallon for diesel, it can be calculated that this truck averaged about 689 BTU per ton-mile (498 KJ per tonne-kilometre). Figures for railways vary from one source to another. R. S. Wallace & Associates [80] show Canadian railways in 1978 at 525 BTU/ton-mile; Transport Canada's study [28] contains a table (Table 1) summarizing a variety of studies with railways shown anywhere from 97 to 420 ton-miles per gallon, or roughly 396 to 1,716 BTU/ton-miles; and another study by Transport Canada [24] shows Canadian railways in 1979 (Table 21) at 3.5 gallons per thousand ton miles or roughly 583 BTU/ton-mile.

4. James S. English Associates Ltd. [56].

5. A study by Transport Canada [24] suggests only a 5% improvement by 1990.

6. See R. S. Wallace & Associates [80] for a complete discussion.

7. P. J. Detmold [40].

8. This illustrative example was developed on the basis of work done by P. B. Hertz at the University of Saskatchewan. The critical data for the two tractor trailers is as follows:

| | Truck #1 | Truck #2 |
|---|---|---|
| Coefficient of Rolling Resistance | .0085 | .0085 |
| Drag Coefficient | 0.98 | 1.03 |
| Total Rolling Resistance (lbs.) where $R = C_R W$ (i.e., ignoring the effect of speed) | 595 | 893 |
| Total Aerodynamic Drag (lbs.) where $R = 1/2\ C_D A V^2$ (where the air density, = 0.0024; front area, A = 106 sq. ft.; and speed, V = 72.9 ft./Sec.) | 663 | 696 |

9. Information on current vehicle weight and dimension regulations may be found in the September 1982 issue of Bus & Truck Transport.

10. J. D. Claxton et al [34] argue that "fuel efficiency standards have had a positive impact on gasoline conservation". E. K. Hansen of General Motors [48] also argues that the fuel economy standards had an important effect on fuel economy. R. F. Webb [102], on the other hand, points to the fact that new automobiles sold in North America already exceed the fuel consumption guidelines (standards). The survey referred to in the text was sponsored by Consumer and Corporate Affairs Canada. The survey showed that in 1978 the average household put 13,500 miles a year on the automobiles owned and consumed 772 gallons of gasoline. In 1980, average miles per household had increased by 2,000 miles and gasoline consumption had increased by 7%.

11. See, for example, the U. S. Department of Transport report [98].

12. E. N. Cantwell et al [32] report that for 1974 cars, fuel consumption was 14% less in comparison to 1967 pre-emission control models - primarily due to retarded spark advance and reduced compression ratios. Fuel economy improved in 1975 (because of the catalytic emission control system?), but overall loss was still 7%. The proposed more stringent standards will result in a loss of 10% - 18%; and the standards proposed for 1982 will result in a loss of another 10%. However, J. D. Murrell [69] (of the U. S. EPA) refutes some of the earlier studies. Based on an extremely detailed analysis, he concluded that there was a 0.8% loss in mpg due to emission control penalties in 1974. (There is also a fuel consumption loss in 1974 due to "vehicle weight mix" changes.) "Fuel economy of the 1979 fleet is 41.5% better than that of 1974; 23.2% derives from technological advancements (although emission standards have toughened), and the balance results from weight mix improvements.

13. McNeal, Hildebrand and Associates Ltd. [66].

14. See, for example, the presentations made at Transportation Fuels Workshop in October 1982 [29].

15. Discussions with P. B. Hertz.

16. Various studies conducted for or by Ontario's Ministry of Transportation and Communications. In addition, a study from the United States [97] suggests that 4.1% of the difference between EPA fuel consumption figures and actual over-the-road experience can be attributed to vehicle condition (e.g., state of tune-up, etc.).

## Chapter 7 Operating Policies

### 7.1 Purpose of Chapter

With prices, infrastructure, and vehicles assumed constant, this Chapter considers the effect of government policies on the operations of the transportation system. Further, the interest is limited to those areas where the operations of the transportation system may have an impact on transportation energy efficiency.

### 7.2 Transportation Systems Operations

The operations of transportation systems encompasses a broad range of subjects. For here, the interest is restricted to six overlapping areas. The first four of these areas are primarily associated with the way vehicles, or vehicles and infrastructure,operate: i) routes - the choice of, or the restriction to various routes (given a fixed infrastructure) affects the total distance of the transportation service and, hence, the total resistance to be overcome; ii) speed - the speed at which vehicles operate is critically important in considering aerodynamic drag and, to a lesser extent, other forms of resistance and the actual

mechanical efficiencies of (some) propulsion systems; iii) flow quality - which overlaps to some extent with the consideration of speed, is the rate of changes in speed in a given time period and is critical in considering some types of resistance and the actual mechanical efficiencies of (some) propulsion systems; iv) operator proficiency - which overlaps with speed and flow quality, is the skill of vehicle operators as these skills affect fuel consumption. The last two areas consider how the elements of the transportation system (operators, vehicles, infrastructure) relate to flows: v) load - the closer a vehicle is loaded to its optimal capacity, the higher the energy efficiency; and vi) service - which overlaps to some extent with the five previous areas and is, in many cases, associated with areas where governments regulate the commercial activities of the for-hire segments of the transportation system.

With a given set of relative input and service prices, with a given infrastructure, and with a given fleet of vehicles, the manner in which the transportation system operates can often be the most critical factor in considering transportation energy efficiency. In practice, of course, the operating aspects are intimately related to the question of prices, infrastructure, and vehicles. That is, each element is in a sense a function of and the product of all the other elements.

## 7.3 Policies Affecting Routing

There are routing choices made in all components of the transportation system, but only a few of these are important in considering how government policies affect energy efficiency. Automobiles and light trucks are effectively free to make their own decisions on routing - given the infrastructure and the various rules (for example, one-way streets) governing the use of infrastructure. The airlines may be regarded as effectively free to determine their own routes with several exceptions noted below. (Additionally, routes imposed by licences are dealt with in Section 7.8.) The marine component, given the limitations imposed by the infrastructure, is similarly free to choose its own routing. Although some past government policies may have been important in considering the location of tracks, the railways are generally free to choose their own routings.

There may be some exceptions to this last statement. For example, interswitching services are regulated (that is, the interswitching of traffic between railways within a certain distance from an interchange point).[1] The 30% customs duty on Canadian rail movements through the United States - particularly the shorter route south of the Great Lakes - could be seen as a policy affecting routing.[2] The

control various government agencies (the Wheat Board, the Grain Transportation Authority, the Canadian Transport Commission) have over the movement of grain and grain cars has some implications on routing. At a very broad level, the whole issue of the railway's relationship with various marine shipping interests and the subsequent decision on which ports are used has some effect on the routing of some traffic (for example, container traffic moving to or from Canada via Saint John, Halifax, or Montreal). However, as most of these issues are very complex and involve some consideration of the demand for rail service, they are not particularly significant in the examination of the narrower issue of the effect of government policies on transportation energy efficiency. (They may be, however, more germane to the subject of total energy consumption.)

One of the components of the transportation system where there are some negative impacts on energy efficiency as a result of routing policies is the trucking industry. This occurs in a variety of ways at both the provincial and local level. First, the designation of certain roads or highways into various classes affects the routes used by some trucks. This, however, is largely connected with the vehicle weight and dimension regulations considered in the previous Chapter. Second, in some municipalities, Calgary is the one most often cited, there are special routes that have to be

used by trucks carrying dangerous goods. Third, in many municipalities there may be bans on some of the larger trucks in certain areas or for certain times of the day. Fourth, and connected with the previous point, most municipalities have bylaws which impose "truck route" systems on the urban road network.

The one known study[3] which has attempted to assess the impact of truck routes on fuel consumption suffers from a number of flaws. Most notably, the wording of the text does not make it clear if the "total fuel consumption" figures apply to all trucks or only those trucks subject to the regulations. With this caveat, then, the study's findings suggest that the existence of truck routes accounts for some 7% to 10% of total fuel consumption.

Discussions with representatives of the airline industry suggest that they see two routing issues arising from government policies (this is independent from any considerations of routes in an airline's licence): routes over certain military zones, and routes over the northern regions of Canada. However, in both cases there have been (or are going to be) some changes which resolve, in part, these issues. It is not clear if any remaining issues are really policies which can be dealt with here or, if they were, the total amount of fuel consumption involved -

considering the entire transportation system - is too minimal to be of much significance.[4]

## 7.4 Policies Affecting Speed

In Chapter 2, the critical relationship between speed and fuel consumption was noted: as speed doubles aerodynamic drag quadruples. For most components of the transportation system, the link between government policies and speed is tenuous. For here, all non-road components can be effectively considered to be responsible for their own decisions on speed. (Any exceptions to this are of relatively minor significance.)

For road vehicles, the relationship between government policies and operating speeds is complex, but at a minimum involves many other considerations besides the relatively simple posting of speed limits: it involves the issue of service - which if adequately incorporated into the measurement of transportation energy efficiency would result in a change in the numerator of the ratio (the "service" factor) every time the denominator (energy input) changed as a result of a change in speed; it involves the issue of the enforcement of speed laws as well as the policies responsible for posting speed limits; it involves a consideration of driver proficiency or motivation and the policies affecting

these factors; in many situations, primarily on urban roads, it involves a consideration of the capacity of the infrastructure to handle a given volume of traffic; and, closely related to the previous point, again primarily in urban areas, there is a close relationship between the consideration of policies affecting speed and policies affecting flow quality.

Therefore, for road vehicles, it is a gross over-simplification to say that the effect of speed regulations is some simple percentage of fuel consumption calculated on the basis of changing the relevant variable in some aerodynamic drag equation. Everything else also changes, including other forms of resistance and often the mechanical efficiencies of propulsion systems.

The empirical work and the literature on this subject suggest two main points. First, considering highways, most authorities suggest that the lower speed limits which were adopted in many provinces a few years ago could have an effect on fuel consumption. There does not appear to be a consensus on just what the optimal speed limit should be.[5] Furthermore, even if it is true that further reductions in speed limits could save more fuel, there are some real concerns about the willingness of most people to accept these and, consequently, there are concerns about the enforceability of any lower

limits. (In fact, there are those who question the effectiveness of the existing speed limits given the problems with enforcement.)

Second, considering urban roads, there are some suggestions that speed limits are too low from the perspective of energy efficiency. That is, low speed limits may have a detrimental effect on flow quality and mechanical efficiencies of most propulsion systems. Obviously, there are many different vehicles using urban roads and it is not clear that there is one optimal speed. There is little hard evidence to determine whether or not municipalities could actually increase speed limits and have any significant effect on energy efficiency (particularly since the critical factor in many cases is the volume of traffic) or whether or not increased speed limits are practical given other considerations such as safety.

With these qualifications in mind, two literature references give some idea as to the potential importance of "slow urban speeds" (and <u>not</u> whether there are any policies which could necessarily do anything about this). One study from the United States, which examined the difference between the laboratory-derived fuel consumption figures for new automobiles and the actual "over-the-road" fuel consumption figures, suggests that 10.6% of the difference may be on account of

slow urban speeds.[6] A Canadian study, examining the energy consumption of trucks in urban areas, suggests that the optimal urban speed would be about 56 km/hr. (or a little higher). Further, the study notes that in Calgary actual speeds are considerably below this optimum, averaging about 61% of the optimum on "stem" driving (driving between two zones) and about one-third of the optimum in downtown driving.[7]

## 7.5 Policies Affecting Flow Quality

There are several ways in which flow quality can affect energy efficiency. The most important of these for road vehicles in urban areas is a combination of the number of stops and starts made during a trip and, more generally, the process of slowing down or speeding up in traffic streams. Given the average level of skill of drivers and the design of vehicles (engines and gearing), the effect of "poor" flow quality is to increase the amount of acceleration resistance encountered and to decrease the average actual mechanical efficiencies of propulsion systems. For aircraft approaching or leaving airports, there are a wide variety of factors which may be incorporated into a consideration of flow quality: the directness of the approach; the amount of taxiing; speed restrictions below certain altitudes; the optimality of ascent or descent

profiles; etc. For the marine components, there is only one known instance of where flow quality might be a factor in considering energy efficiency; this will be dealt with (and dismissed) below. For railways, there are some aspects of flow quality - such as "meets and passes" - that will also be dealt with (and dismissed) below.

### 7.5.1 Road Vehicles

Considering, first, road vehicles in urban areas, government policies which affect flow quality may be conveniently labelled "Traffic System Management" (TSM); although, it is recognized that this is not entirely accurate. Some aspects of TSM involve infrastructure as well as the rules governing the use of infrastructure; and, such issues as parking prices (considered in Chapter 4) also may be considered a part of TSM.

TSM consists of speed limit regulations, stop sign/yield sign/signalling systems, pavement markings, traffic direction rules, traffic separation, special rules on such matters as reserved lanes, all the various "parking" or "stopping" regulations, and so on. It is difficult to develop a compendium of these TSM policies in various urban areas, and it is even more difficult to develop good quantitative information on the effect on energy efficiency as a result

of changing one particular TSM item. Therefore, for here, the TSM policy issue has to be seen broadly as all those rules/regulations/practices that either increase or decrease what might be described as an "ideal free flow" of traffic.

There are numerous sources of information on the effect of TSM policies on energy efficiency; however, some problems should be pointed out. First, there is no consistency from one source to another in categorizing groups of TSM policies, so it is sometimes difficult to make comparisons. Second, there is a pronounced tendency to over-simplify this subject and (possibly) to over-estimate the supposed benefits. This is particularly true in urban areas where much of the automobile travel occurs during peak periods (rush hour) where the real "flow quality" effects are primarily related to the capacity of the infrastructure and only secondarily to TSM "rules, regulations, procedures". (For example, there is no benefit to a "right-turn-on-red" regulation in traffic conditions which do not allow such behavior.) Third, there is one severe difficulty in extrapolating information from one TSM study to either conditions in another area or more generally to all Canadian urban areas. That is, a study of the supposed benefits of "removing stop signs" or "traffic signal coordination" or any of a variety of TSM changes is totally useless in estimating benefits elsewhere unless some information is available on the traffic conditions and/or TSM policies in this other place.

There have been various studies on this subject. One such study reduced the whole subject of urban TSM to the simple "rule of thumb" that the effect of traffic management policies which reduced average trip time by 10% was a 6% to 7% saving in fuel consumption.[8] Another study from the United States, which examined both infrastructure changes and TSM rules or procedures, suggests that a series of measures which would improve traffic signal systems could reduce urban automobile fuel consumption by something in the order of 4%.[9] A Canadian study evaluated 21 measures (many of which were improvements to urban infrastructure): 6 of these fell under the heading of "traffic control" and were estimated to result in an energy saving of 11% to 42% (although the most significant impact resulted from "traffic responsive operations", which probably should be included with infrastructure changes rather than TSM rules and procedures).[10]

An even more recent Canadian study (still in the draft stage), has estimated that the 7 best "traffic" measures (all having to do with stop signs, yield signs, or signals) would save 1.37% of the fuel used in all Canadian urban areas.[11] (The results are much more impressive if just large urban areas are considered.) Again, as with earlier studies, these proposed "transportation energy management" measures are not just simple "rule" or "procedural" changes. That is,

they all have costs associated with them and they generally involve some modifications to existing infrastructure. The costs (depending on the size of the urban area) range from 1¢ per litre of fuel saved for "replace stop with yield" up to 15¢ to 20¢ per litre of fuel saved for "interconnect signals".

A final study approaches the problem from another direction. That is, rather than trying to measure the impact of any given changes, the attempt is to answer the question "What would total energy consumption be under various flow conditions?" This study, from the United Kingdom, suggests that if it were possible to alter the quality of flow from what the authors characterize as "peak" to "off-peak" conditions, a total of 1.5% of energy (all vehicles) would be saved and a further 4.6% of energy would be saved by moving from "off-peak" to "free flow" conditions.[12] This approach begs the question as to whether or not TSM policies can have such effects on flow, but it does help put the issue in perspective.

Finally, to characterize the existing TSM policies in Canada, it has to be pointed out that the general goal of such policies - to move the existing number of vehicles demanding road space as smoothly, efficiently, and safely through the urban road network as possible - coincides with the objective of keeping transportation energy efficiency at as high a level as possible.

(This point often seems to be forgotten.) While it is true that there are trade-offs to be made (for example, safety versus fuel efficiency), while it is true that there are always areas where increased budgets could improve infrastructure (and, hence, flow quality), it would be incorrect to simply label the existing TSM policies as having a negative impact on energy efficiency. At best, there are some slight changes in emphasis that could result in improvements to energy efficiency.

The two most frequently cited changes in emphasis are: i) minimizing the number (and duration) of stops, and ii) increasing average speeds (decreasing journey time). However, there is no real consensus on the importance of these issues, nor has there been enough work done on the practicality of introducing TSM changes (in particular, hard estimates on costs and estimates on other policy objective "trade-offs").

### 7.5.2 Aircraft

The subject of energy use in the air industry has just recently been examined in a study sponsored by the Department of Energy, Mines and Resources.[13] Many of the points covered under what the study terms the "external environment" are related to the subject of how government policies affect the flow quality of aircraft. (In actual fact,the topics covered

under this heading go somewhat beyond just flow quality.) From a survey of the airlines, the study lists twenty comments, all of which have some bearing on aircraft fuel consumption and the role of government. However, the difficulty in evaluating these comments is that only the carriers' points of view are expressed. The carriers see a number of procedures where improvements could be made. These are under the heading of i) air traffic control, ii) taxiing/take-off procedures, iii) altitude/tracking procedures, iv) descent, v) ground side requirements, and vi) weather forecasting. A number of the comments incorporate changes in equipment (which are not of concern here) and a number of comments concern routing (which was the subject of Section 7.3).

In a subsequent chapter of the report, the authors list a long series of what they call "energy cost savings". (There is no explanation as to how the figures were developed.) Most of the topics covered under the airlines' twenty comments appear to be covered in two sections of this list: "optimal take-off-cruise-descent" which is shown to result in a 1% - 3% energy cost saving; and "air traffic control improvements" which are shown to result in a 1% - 5% energy cost saving. What is not clear from the text, however, is whether the responsibility for these improvements rests in the hands of the air traffic controllers or the

airlines. Further, it is not clear whether these improvements are really procedural in nature or whether they depend on new equipment. The best the authors offer is that "more cooperation" is required between pilots and air traffic controllers, and "some other areas for development include . . . [a series of the airlines' comments]".

This, then, is not much help in attempting to find out if there are any positive or negative impacts on energy efficiency arising from the way airports and related services are run. In a way similar to the views expressed on how urban traffic managers conduct their business, it has to be presumed that the general objectives of running airports and air traffic services complement the attainment of the highest level of energy efficiencies possible. This, of course, is not to deny that there is always room for improvement. The most positive aspect of this study on energy management in the airline industry is that those areas listed as potential "energy cost savings" - whoever's responsibility - are relatively minor. Further, they are insignificant in comparison to what the authors show to be the potential for changes to aircraft and other matters falling under the control of the air carriers.

In discussions with the industry, one policy area which was believed to have a detrimental effect on fuel consumption

was referred to as "noise abatement procedures". These procedures involve a number of the areas covered in the recent Energy, Mines and Resources' study. As there is no separate quantification on how serious an issue this is (nor is there any indication on how feasible it would be to change any of these procedures), it is assumed that the impact of this policy is contained within the 1% - 3%, and 1% - 5% figures given in the study.

### 7.5.3 Marine and Rail

In discussions with industry representatives, there were a couple of minor places where improvements to flow quality would be a factor in marine or rail energy efficiency. The marine industry mentioned the possibility of some procedure whereby ships which had to pass through locks or canals could be scheduled so that, long before vessels ever reached the lock or canal, the optimal speeds could be maintained. The rail industry mentioned various developments in the area of traffic control systems. However, although these areas are not totally independent of government policy (for example, there is some government funding), they are not really part of the consideration of how or where government policies affect operations - independent from vehicles, equipment, or infrastructure.

The most important point to note about these two components of the transportation system is that the industry spokespersons did not identify any significant government policies affecting flow quality (that is, independent from policies affecting the industry's ability to finance new vehicles, equipment, or infrastructure).

## 7.6 Policies Affecting Operator Proficiency

By some accounts, the issue of operator proficiency is one of the single most important factors determining transportation energy efficiency. For example, one enthusiastic account on automobile drivers notes that a certain type of driving can reduce energy requirements by 60%.[14] The author does not suggest, however, that this style of driving is very practical: his point was more to show how much fuel consumption is affected by driving practices. Actual controlled tests of automobile drivers have shown that fuel consumption can vary by as much as 50% between the "worst" and the "best" drivers.[15]

Trying to sort out where and to what extent government policies are involved with the issue of operator proficiency is not easy. At a broad level, it could be argued that since governments are involved in both the education business and the business of licensing most transport operators (all road drivers, pilots, and captains) there is a very close link between government

policies and operator proficiency. This is true to a certain extent, but as a practical matter the view adopted here is that most commercial segments of the transportation system are most directly responsible for their own operator proficiency.

The degree to which these commercial sectors strive to improve operator efficiency may be affected by government policies, or various co-operative educational/training programs. The importance of these areas should not be minimized, even if it is almost impossible to find any reference material on the effectiveness of these policies.

For here, then, the attention is focused on policies which have an impact on private automobile (and light truck) operators. This is where the overlapping nature of the subject matter becomes very evident. The term "operator proficiency" can include many aspects of the knowledge of and the skill of drivers, including the choice of vehicles, the choice (or use of) associated equipment (air conditioning, radial-ply tires, roof racks, and so on), the maintenance of vehicles and equipment (tune-ups, tire pressure, etc.), and the actual manner of operating the vehicle which is the main concern here. This last area, the manner of operating a vehicle, includes such facets as the following: i) keeping windows closed while driving, ii) lower speeds, iii) the distance maintained between two vehicles, iv) maintaining a constant speed, v) idling, and so on.[16]

In considering policies which have an impact on operator proficiency, there are four somewhat interrelated areas. There is the licensing system for drivers which falls under provincial jurisdiction. There are training or educational programs for new drivers which may or may not be a part of the licensing system. This is primarily a provincial matter; although, in some provinces there may be some local government involvement through the public schools. The third area can be called "promotional" policies which are aimed at all drivers; and, the fourth area might be thought of as the governments' training or promotional efforts with their own drivers or employees. All three levels of government may be engaged in activities in these last two areas.

In terms of the licensing system, provinces have differentiated among different classes of drivers and some of this differentiation involves the question of skill. However, there is no energy-efficient component to the testing procedures.

In terms of driver training and educational programs, procedures vary from province to province: there are some programs conducted through the school system, there is a general licensing procedure for instructors, and there are a number of driver training/educational programs conducted by the private sector. With possibly one or two exceptions, however, there is not much emphasis

on teaching fuel economy driving techniques. Only two provinces are known to be doing something in this area: Ontario conducts seminars for driving instructors and sends out newsletters on the subject (however, according to an Ontario survey, only 10% of the local governments had either implemented or taken under consideration programs addressing energy conservation in driver training programs offered by the Board of Education.);[17] Manitoba has some "informational" role with respect to the training program conducted through the high schools.

As for promotional policies (that is, over and above those incorporated into any of the driver training/educational programs for new drivers), there is some activity. For example, Ontario has a "Drivesave" program which includes such things as a mailing program (incorporated into the licence renewal system); some other provinces have instituted various "information" programs.

In terms of the last policy area, concerning government employees and drivers, fairly wide-spread "energy conservation" programs have been undertaken at both the federal and provincial level. Some aspects of these programs appear to touch on the issue of automobile energy efficiency as it relates to operator proficiency. It is difficult to know how much activity there is at the local government

level. According to a survey conducted in Ontario, only 36% of all municipalities surveyed had in effect formal energy-efficiency guidelines for their own fleet operators (another 24% had guidelines under consideration) and only 7%, in 1981, had provided training for and testing of vehicle operators.[18]

## 7.7 Policies Affecting Loads

As the discussion in Chapter 2 made clear, the issue of payload is critical in considering transportation energy efficiency. It is obvious that even with the best infrastructure, the most efficient vehicle, and a highly skilled operator, transportation energy efficiency is zero if a truck, a train, or other freight vehicles carry no load.

The relationship between government policies and payloads, however, is obscure. For trucks, the issue of maximum vehicle size and weight regulations (Section 6.3) has a bearing on the subject, but need not be considered again. For automobiles and light trucks, the whole "operator proficiency" area can be related to a consideration of loads if a part of "proficiency" is the knowledge that more people in a car is more efficient than fewer people.

For many of the commercial, for-hire (and sometimes, private) components of the transportation system, the whole area of service - considered in the next section - is germane to the discussion of government policies affecting loads. Finally, for the entire transportation system, the demand for service - and, obviously, government policies which affect the activity system - is of critical importance in considering loads.

A brief consideration of each component of the transportation system reveals that there are few, if any, policies that affect loads by themselves. That is, in almost all cases, the link between policies and loads is through some other area: input prices, service price, infrastructure, vehicles, or some other area considered in other sections of this Chapter such as operator proficiency or policies affecting service.

For automobiles, it is known that average loads are only in the range of 1.4 passengers; in fact, on journeys to and from work, it is even lower.[19] The most important factor accounting for these low load factors is the consumer's own tastes and preferences (which are assumed constant in this study). Of course some government policies affecting the price of fuel may have an impact here, but if they do, their assessment has to be included in Chapter 4. Other government policies (primarily provincial) may be seen as promoting the idea of higher loads: anything from the

pure promotion of ride-sharing, to the addition to infrastructure (parking lots alongside highways) to facilitate ride-sharing, to the changing of legislation in some provinces to permit the sharing of costs without bringing the operation under the "for-hire" regulatory system. In some government departments there are programs designed to facilitate the matching of ride-sharing passengers with drivers, and there is some government assistance for industries wishing to implement similar programs. At the local level, the policies on the provisioning of, and in some cases, the pricing of parking spaces also have an effect on load factors.

However, all of these programs either deal with other elements of the transportation system (prices, infrastructure, or service regulation) or else they work through the mechanism of changing the demand for travel (the "promotional" programs). There are no known policies directly affecting minimum loads ("automobiles must carry . . .")

With respect to trucks, and ignoring any previously considered price, infrastructure or vehicle issues, there are several areas where government policies may affect loads. The most important may be service regulations which are considered in the following section (it may be noted here, though, that the evidence on this issue is inconclusive). Other areas may

include some of the provincial and (forthcoming) federal regulations on commodities which may be carried together. For example, there are regulations at all three levels of government which are concerned with the processing, distribution, and sale of food products. Some aspects of these regulations affect the manner in which various products are transported. To illustrate, one cannot move meat products with livestock, some perishable products have to be transported in special equipment, etc. (The regulations do not spell things out in such simple terms, of course. However, this is their effect.) Or, as another example, the regulations which are now being drafted (federally) on dangerous goods will, for example, prohibit loads containing both explosives and poisons. All of these types of regulations have a potential impact on load factors for trucks. There is no empirical information, however, on whether there is any significant actual impact.

The air, marine, and rail industries are essentially similar to the trucking industry. That is, aside from where government policies affect some other element of the transportation system, there are few policies which directly affect loads and which could be considered within the "feasibly" changeable category. The aspects of service regulation are considered in the next section; any other regulations comparable to the "food products" or "dangerous goods" categories considered

under trucking are so obviously necessary that it does not merit considering whether or if there are any impacts on energy efficiency. On this last point, it is significant to note that none of the industry representatives contacted considered this area very important.

## 7.8 Policies Affecting Service

The notion of "transportation service" encompasses a broad range of variables in the numerator of the transportation energy efficiency ratio. In most cases, these are difficult to quantify and, as a result, are often treated qualitatively in transportation studies. For here, the interest is in those areas where government policies affect any aspect of service, including frequency, routes or customers served, speed of conveyance, safety, and so on; and, where these effects on service have some potential to affect transportation energy efficiency. This is difficult to do as a change in service changes the numerator in the ratio that is being examined - so it is hard to avoid "apples and oranges" comparisons; and, government policies affecting prices, infrastructure, vehicles, and operating policies also affect service.

To reduce this to manageable proportions, the prime focus on policies affecting service is on those segments of the

transportation system which are directly regulated. This is often referred to as "economic regulation" and, although there are several instances of where the focus is broader than this, it is convenient to consider "economic regulation" as the subject of this section. (The regulation of rates, also a feature of economic regulation, was considered in Chapter 4.)

The components of the transportation system which are regulated include i) the taxi segment of automobiles - generally at the local level; ii) the intercity bus industry - under provincial control (with the exception of Newfoundland); iii) most of the for-hire segments of the trucking industry - all three levels of government are involved, although the provinces are by far the most important; and, iv) the commercial airlines - by the Canadian Transport Commission. The rail and marine components are also regulated to some extent, but this may be regarded as relatively unimportant here.

In the last decade or so (the events leading up to the 1967 National Transportation Act can be considered a good starting point), there has been considerable discussion on the effects of regulation. Those in favour of the regulation of commercial, for-hire transportation services tend to see market forces as being so strong that there are some undesirable consequences.

In particular, the argument is often advanced that unbridled competition results in an unstable industry characterized by either financially weak firms or firms that engage in unsafe operating practices. This group also often argues that the unregulated market forces do not produce the service levels that may be desirable from society's point of view.

The other camp in this debate argues that regulation only protects the weak and inefficient firms; that very often regulation results in a situation where shippers or travellers are paying prices that are too high; and, that some transportation prices often subsidize the cost of other transportation services. This "deregulation" camp has been largely responsible for some significant relaxation of regulation in the United States (air, trucking), and many investigations or legislative committees in Canada.

The arguments by both sides in this debate are often very eloquent. Further, they are sometimes backed up with empirical evidence; although, in most cases the evidence is contested by the opposing camp. But, it is not just the debate over the validity of the data which makes the job of this study difficult. Rather, it is a combination of the lack of conclusive evidence and the very concept

of the definition of transportation energy efficiency which makes it almost impossible to determine whether or not regulation has a positive or negative impact on energy efficiency.

Consider, for example, a transportation service provided under a regulatory environment. If it could be shown that the rates for this service were higher than would be the case in the absence of regulation, if it could be shown that the cost structure of the firm providing the service was higher than would be the case in an unregulated environment, or if it could be shown that such physical measures of productivity as capacity utilization were lower than would otherwise be the case, it would be legitimate to conclude that regulation caused inefficiencies. (Rates, costs, and capacity utilization are, of course, interrelated. Further, there may be many reasons other than the existence of regulation for the resulting higher or lower rates, costs, or capacity utilization.) In considering this transporation service from the point of view of transportation energy efficiency, all of these other considerations and most importantly the demand for the service are assumed constant. So, in the first instance, it is not possible to directly address the question of how or whether regulation affects energy efficiency.

This is somewhat analogous to the difficulty that would be encountered in trying to decide whether the policies responsible for VIA Rail had a positive or negative impact on energy efficiency. On the one hand, if it were true that the rail operation used the optimal type of equipment and infrastructure, and that the operating procedures were optimal - given the level of demand, it could be argued that the energy efficiency of the system was as high as could be expected. This observation, however, overlooks the issue of whether or not the whole VIA Rail operation is inefficient given that it cannot operate without a subsidy or given that if market forces were allowed to have their full effect the resulting fares might reduce the number of passengers to almost zero.

With these difficulties noted, then, what are the regulatory policies in Canada and what evidence exists as to the impact of these policies?

First, the issue of taxi regulation can be dismissed as it is of no major concern to this study. As noted in Chapter 4, the limited available evidence suggests that taxis represent such a small component of the transportation system that it does not seem that the effect of regulatory policies could be of any significant consequence to the overall energy efficiency of the transportation system.

(While this is very "soft" evidence, even if there were 25,000 or 50,000 taxis in Canada, it hardly seems likely that they could account for more than 1% of total transportation fuel consumption in Canada.[20]

Second, in considering the intercity bus industry - which is quite "tightly" regulated - the few studies on the subject cannot be used to reach any firm conclusions on whether the existence of regulation has an impact on energy efficiency. There are some tentative suggestions from these studies that there have been occasions when bus fares were higher than those that would have existed in the absence of regulation; there are some hints that, in some instances, service offered has been at a higher level than under competitive conditions; and, there are some suggestions that on some occasions where larger vehicles are used than those thatwould be used under an open market situation.[21] However, these tantalizing suggestions are not used by the authors to reach any definitive conclusions on what the effects of regulation are. In any case, for here, the most critical point to note is that this component of the transportation system only accounts for 0.2% of total transportation fuel consumption.

Third, considering trucking regulation, it is probably true that there has been a general tendency to relax some aspects of the regulation of entry and the associated regulation of what routes, customers, or communities can be served by a licensed firm. This relaxation, however, would be hard to quantify with any available empirical evidence. Many provinces which do regulate for-hire trucking, have conducted reviews of the regulatory systems over the past few years and although there have been few clear deregulatory moves (comparable to what happened in the United States in 1980), there is a sense that regulatory agencies are more inclined now than they were ten years ago to let market forces have a greater role in influencing the conduct of the industry.[22]

The evidence on the effect of regulation on the trucking industry is inconclusive. Most research in this area concentrates on the fact that intra-Alberta trucking is effectively unregulated. The analysts use this fact to make comparisons with other regulated provinces in an attempt to determine what the existence of regulation does to the industry. One of the latest such studies, which culminated a long series of attempts to find some answers to these questions, comes close to suggesting that regulation leads to inefficiency. (Again, this is the broad notion of efficiency, not the narrower issue of energy efficiency.)

While the technical details of this study are complex, the following are the pertinent observations. The analysis uses a statistical technique that attempts to hold "all other things equal" (for example, lower or higher wage rates in one province). Based on this, the authors conclude that unregulated truckers in Alberta are more efficient than their counterparts in regulated Ontario and Quebec. There are two possible reasons for this: different traffic patterns resulting from different demands for service; or, the absence or presence of regulation. The authors attempt to calculate whether the first of these possible reasons accounts for the observed differences in efficiency. They find no evidence that it does. They conclude: "Inefficiencies due to regulation remain a possible explanation for the observed cost differences."[23]

An even more recent federal government paper, which attempts to use this and all other studies on the question to reach some policy conclusions, does not make too much of these findings. The report notes that "The superior performance of unregulated intra-Alberta carriers seems to imply that economic regulation may directly or indirectly cause the inferior performance of carriers operating elsewhere". Without being clear on how much weight they give to this tentative finding, the authors then proceed to note that there are other factors in Alberta which favour trucking

operations: higher speed limits, the allowance of larger combinations of trailers, and (on the Edmonton-Calgary route) the "nearly ideal operating conditions".[24]

The same type of debate surrounds the question of the regulation of the airline industry. In this case, proponents of deregulation point to the example of the United States; those favoring continued regulation in Canada tend to argue that the market in Canada is quite different than in the United States. This second group, not surprisingly, includes the existing regulated carriers: " . . . excessive competition, either in a regulated or deregulated environment, means smaller and less fuel efficient types of airplanes".[25]

In terms of describing Canada's air regulatory policies, it is fair to observe that there has been a significant shift over the past decade from what might have been called "a reasonably controlled situation"to the current more "open" situation. One study which has examined air regulation in Canada notes that as of 1979 the restrictions on CP Air (in terms of its ability to compete with Air Canada) have been removed. Further, prior to about 1977/78, the Canadian Transport Commission's licensing decisions rarely permitted head-to-head competition. As of October,

1980, however, there were 262 routes (city pairs) where issued licences permitted two or more carriers to compete. "As of October 31, 1980 . . . over 83 percent of the high and very high density markets (over 70,000 passenger trips) and 46 percent of the medium density markets (between 10,000 and 70,000 passenger trips) were served by more than one licensed unit toll air carrier".[26]

The most recent statement on the subject of air regulatory policies, by the Deputy Minister of Transport Canada, suggests that Canada is not going to deregulate along the lines of the United States. "A high degree of competition among Canadian carriers already exists . . . "[27] This statement was made in the context of a new air policy being considered by the federal government in 1981 and 1982. Although this new policy has some significance for the role of various airlines and although some aspects of this new policy represent a relaxation of regulatory controls, the basic existence of the regulatory framework is preserved. (Carriers will still have to apply for licences.)

The same federal study that attempted to draw some conclusions with respect to the effects of trucking regulations, examines the evidence on the effect of air regulation. Although the conclusions are a little vague (the study uses phrases such

as "the likely implications"), the authors suggest that deregulation would have both positive and negative impacts. However, except for the possibility that smaller aircraft would be used in some markets and the possibility that there would be over-capacity in some markets, it is difficult to infer very much in terms of the effect of regulation on energy efficiency.[28]

Although aspects of the rail industry are regulated, most of the issues involve a consideration of rate regulation (which, as discussed in Chapter 4, can be considered to be effectively non-existent in Canada). In terms of the marine industry, the regulated segment is too small to be considered significant here: package freight on the Great Lakes (which has disappeared in any case), the Mackenzie River and the Western Arctic, restriction on non-commonwealth vessels in the coasting trade, etc.

## 7.9 Summary

Government policies affect the operating practices of the transportation industry. The most important way this occurs is probably those policies affecting prices and to a lesser extent infrastructure and vehicles. For here, however, the assumption is that these influences are held constant and the focus is on policies affecting operations with a given

set of prices, infrastructure, and vehicles. The important findings of this Chapter are as follows:

Routing: at the provincial and local levels of government, there are some regulations affecting the routes trucks use. Some studies have indicated that the existence of urban truck routes may account for 7% to 10% of total truck fuel consumption: it is believed that these percentages apply to only the fuel consumption of the trucks required to use the truck routes. It is not possible to accurately extend the results of this one study to all urban areas in Canada; although, might be possible to speculate on the upper boundary of how important this issue is. Specifically, the figures on Table 2.1 indicate that medium and large trucks account for over 7 billion litres of fuel consumption. Given the way truck route bylaws work - for example, garbage trucks or trucks having to make a pick-up or delivery are not bound to follow roads specifically designated as a "truck route" - and given that a good deal of total truck distance is intercity, it is inconceivable that any more than half of this fuel consumption is affected by truck route regulations.[29] If this is the case, 7% to 10% of one-half of total medium and heavy truck fuel consumption is in the order of 1% of total transportation fuel consumption in Canada. This, of course, is a highly speculative number.

Although there are some other routing issues affecting other components of the transportation system, none of these are very significant here.

Speed: speed is a critical factor in considering energy consumption. The only components of the transportation system where government policies are important in considering this issue are those using roads. While there have been some suggestions regarding changes to both highway and urban speeds, it would be simplistic to consider existing policies as having either a positive or negative impact on energy efficiency. (This statement does not deny that vehicles operating at lower speeds on the hignways could reduce fuel consumption with some slight changes to service, nor does it deny that somewhat higher speeds in urban areas - if these higher speeds were possible - might be desirable.)

Most other commercial sectors of the transportation system have the primary responsibility for controlling speed, independent of any influence from government policies.

Flow Quality: improved flow quality would have a positive impact on energy efficiency for all components of the

transportation system. There are some suggestions that in the case of road vehicles in urban areas and in the case of aircraft landing or taking-off some changes in emphasis in government policies might lead to improved energy efficiency. The empirical evidence on how important these changes might be is poor and the feasibility of introducing such changes given other policy considerations (particularly safety) is not known.

Operator Proficiency: other than some "promotional" activities, there are few government policies which deal directly with the issue of operator proficiency - at least as proficiency relates to transportation energy efficiency. Primarily in respect of the non-commercial sectors of the transportation system, the very key role played by proficiency in determining energy efficiency suggests that the absence of many government policies in itself could be considered as a policy (a "non-policy") having a negative impact on energy efficiency. However, this is said without knowing whether or not some training procedures built into the driver licensing system would be effective. It may well be that the greatest means to teach the necessary skills is the continuation of the current promotional-type activities by the federal and (several) provincial governments coupled with high energy prices.

Loads: there are no significant policies affecting loads (that is, of course, independent from policies affecting some other element of the transportation system which might also affect loads, or independent from policies which change the demand for transportation service).

Service: it would be incorrect to say that there were no regulatory policies which in some instances had an impact on energy efficiency. However, the empirical evidence of what the impact or importance of these policies might be is either lacking or inconclusive. In any case, if the total fuel consumption of those components subject to effective regulation (entry, service) is summed from Table 2.1, this issue cannot possibly affect more than about 12% of total transportation fuel consumption. That is, from Table 2.1, the total fuel consumption of for-hire trucks (not all of which are regulated), intercity bus, and aircraft (excluding foreign) is 6.6 billion litres.

## Notes to Chapter 7

1. See T. D. Heaver and J. C. Nelson [50], pp 217-219.

2. See T. D. Heaver and J. C. Nelson [50], p 122; or, Transport Canada [27] p 35.

3. University of Calgary [99].

4. According to the president of the Air Transport Association of Canada [68], airlines are now permitted to fly overmost of the military zones during certain times of the day. It is understood from the Association that there remain a few other zones where they would like to see similar agreements. The "northern route" issue is not entirely understood (i.e., as to whether it is just a matter of policy or whether it requires some change to infrastructure). In any case, it appears that some resolution is about to be found on the issue.

5. The "classic" work on this subject is P. J. Claffey [33]. His work, based on automobiles from the mid-1960s, suggested an optimum speed of 35 mph. However, more recent work by W. R. Shoemaker [89] seriously questions the continued relevance of Claffey's figures.

6. M. Dillard [41].

7. University of Calgary [99].

8. M. H. L. Waters [101].

9. F. A. Wagner [100]. This study also assessed other changes which have not been reported in the text.

10. IBI Group [53].

11. IBI Group [54].

12. L. Gyenes [47].

13. James S. English Associates Ltd. [56].

14. P. B. Hertz [52] lists something like 30 "tips" for drivers. He claims that "momentum driving", which seems to involve considerable coasting, can reduce energy consumption by 60%.

15. M. H. L. Waters [101].

16. See P. B. Hertz [52], or any of a wide range of the promotional material available from federal and provincial governments for a complete discussion of driving "tips".

17. Ontario, Ministry of Transportation and Communications [73].

18. Ontario, Ministry of Transportation and Communications [73].

19. D. J. Reynolds [87].

20. The limited evidence presented in Chapter 4 suggests that there might be 25,000 taxis in Canada. Suppose, in fact, there were 50,000 consuming an average of 10,000 L of fuel annually (about 4 times the average, or roughly 27 L every day of the year); in total, this would amount ot 0.9% of total transportation fuel consumption.

21. Transport Canada [27].

22. The clearest moves towards "deregulation" in the past few years have been such things as Ontario's decision to allow intercorporate hauling (in effect, two related private trucking operations to operate as one), Ontario's decision to exempt some produce haulers from the licensing system, or Manitoba's decision to exempt some forms of grain hauling from the regulatory system. Although it is known that Ontario is studying the effects of its decision on intercorporate hauling, at the time of writing, the Ontario report was not available.

23. James J. McRae and David M. Prescott [67].

24. Transport Canada [27].

25. C. H. Glenn (of Air Canada) [45].

26. Canadian Transport Commission [6].

27. A. Kroeger [63].

28. Transport Canada [27].

29. Another way of tackling this problem is to extrapolate the fuel consumption figures from the University of Calgary study [99] for the year 1971. This study suggests that trucks moving goods in Calgary consume 27.7 million gallons of fuel, or roughly 69 gallons per capita. About 55% of Canada's population (1976) lived in the major urban areas which is where significant truck route effects on truck fuel consumption would be found. Extrapolating for 1980, then, (and ignoring any changes in fuel consumption per person over the decade), there might have been 4.1 million litres of fuel used by urban trucks in urban centres with truck route bylaws. This is 54% of the fuel shown on Table 2.1 for medium and large trucks; however, if the trucks which are not subject to the bylaws were eliminated, this would be less (probably considerably less) than 50%.

# Chapter 8 Summary and Conclusions

## 8.1 The Approach to Evaluation

Precise quantification of the impacts of government policies on transportation energy efficiency is not possible. The more important reasons for this include i) the poor data base on energy consumption and some aspects of the transportation system; ii) the limitations of the available literature sources on the nature, effects, and importance of various policy areas; iii) the different opinions of government and industry sources; and iv) the extremely complex nature of the transportation system - in particular, the dynamic interaction of this system with governments and the activity system. These factors make it necessary to address the question of impacts in a relatively qualitative, and often judgemental manner.

Observations and conclusions derived in such a manner are debatable. Indeed, many of the findings of this study should be debated.

The approach adopted here can be best characterized as one of "deductive analysis". That is, policy areas - or policy areas affecting some components of the transportation system are progressively eliminated on the basis of the available evidence. This process permits the successive elimination

of policy areas which have "no" impact, "little" impact, and "some" impact, in order that attention can be focused on those policy areas which have the "greatest" impact. (These four categories are defined in subsequent sections.)

The one inherent limitation to this approach is that the cumulative or combined effect of many relatively unimportant policies tends to be overlooked. This is unavoidable. The objective here is to examine broad policy areas affecting the broad segments of the transportation system.

## 8.2 Policy Areas - Transportation System Components

Table 8.1 presents a matrix of all policy areas and all components of the transportation system considered in the preceding Chapters. The construction of this matrix introduces the first major element of judgement into the process of evaluating policies. That is, the very choice of which columns constitute a "component" and which rows constitute a "policy area" is both subjective and of some importance to the subsequent determination of impacts. There is no known way of avoiding the subjective nature of these choices.

The explanation for the choices that have been made with respect to the columns of this matrix are straightforward.

First, the general format of dividing the transportation system into six major components - automobiles, trucks, transit and intercity bus, air, marine, and rail - has been followed, with one exception. The exception concerns "light trucks" which have been included with automobiles, on the basis that the vehicle technology, the technical factors affecting energy efficiency, and the transportation demand for "light truck travel" is more similar to automobiles that it is to the larger trucks. Second, the air, marine, and rail components have been further sub-divided:

- the air component has been dividied into the "large, domestic" segment (Level I to V commercial carriers) and "all other" (scheduled foreign and everything else). The rationale for this is that the large domestic carriers accounts for 82% of air fuel consumption, and that these carriers are the major users of the airports which are affected by federal policies. (The scheduled foreign carriers are, of course, very similar to the large domestic carriers. However, it is presumed that the subject of how Canadian policies affect these carriers is of less importance here.)

- the marine component has been divided into "domestic carriers" (for-hire, private, or government) and "all other" (foreign carriers operating internationally and all the fishing, government service, pleasure operations). The rationale is, in part, imposed by the limitations of the available data sources, but also is an attempt to isolate the domestic "carrier" segment from the foreign (over which it may be assumed Canadian policy has little impact) and the "other" (which may be influenced by other types of policies than those affecting "carriers").

## Table 8.1: POLICY AREAS - TRANSPORTATION SYSTEM COMPONENTS

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | Area | Specific Type | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | LARGE DOMESTIC | | ALL OTHER AIR | | DOMESTIC CARRIERS | | ALL OTHER MARINE | | FREIGHT | | PASSENGER | |
| | | | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% |
| 2. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | Registration Taxes | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14. | Infrastructure | User Fees | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15. | | Indirect Subsidies | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16. | Service | Regulated Rates | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17. | | Subsidies | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Routing | Design/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21. | Veh. Speed & Performance | Design/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22. | Flow Quality | Design/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Fuel Economy | Guidelines | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31. | Routing | Regulations/By-Laws | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Speed | Regulations/By-Laws/Enforcement | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Service | Economic (Direct) Regulation | | | | | | | | | | | | | | | | | | | | | | | | | | |

- the rail component has been divided into "freight" and "passenger" segments on the grounds that most policy considerations traditionally make this distinction.

Ideally, there should be further sub-divisions of these components: for example, "medium and heavy trucks" into for-hire, private, and "other" segments; "transit and intercity bus" into three or four segments; etc. Data constraints prevent this level of disaggregation.

The rows on this Table, the "policy areas", follow the description developed in Chapters 4 through 7. There is, of course, some over-simplification in the titles used to label these rows. Each column has been divided into three areas, "F" for federal policies, "P" for provincial policies, and "L" for policies emanating from local governments.

## 8.3 Policies With No Impact

The first step in assessing the importance of policy areas is to identify those areas on the matrix where there is no impact. "No impact", in this context, has to be understood as i) absolutely no impact, ii) a possible impact with no known information to suggest any significance, or iii) a possible impact which, if measurable, is too insignificant to be of concern here. These "no impact" areas are shown on Table 8.2 with three symbols:

# Table 8.2: POLICY AREAS WITH NO IMPACT

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | | | TRANSIT | AIR | | | | MARINE | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | & INTER-CITY BUS | LARGE DOMESTIC | | ALL OTHER AIR | | DOMESTIC CARRIERS | | ALL OTHER MARINE | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F P L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | 7.2% | | | 1.6% | 3.1% | | | 3.7% | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | X | | | X | X | | | X | | | X | | | X | | | X | | | X |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | X | | | X | * * X | | | X | * | * | X | | | X | * | * | X | | | X |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | X | | | X | * * X | | | X | * | * | X | | | X | * | * | X | | | X |
| 5. | Vehicle | Special Sales Tax Exemption | | | | X | | | X | * * X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 6. | | Excise Tax | | ? | X | X | X | X | X | X X X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 7. | | Customs Duties | | ? | X | X | ? | X | X | ? X X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X |
| 8. | | Investment Tax Credit | | | | X | | | X | * * X | | | X | * | * | X | | | X | * | * | X | | | X |
| 9. | | CCA | | | X | X | | X | X | * X X | | X | X | * | X | X | | X | X | | X | X | | X | X |
| 10. | | Special CCA | | | X | X | | X | X | * X X | | X | X | * | X | X | | X | X | | X | X | | X | X |
| 11. | | Grants/Assistance | | ? | ? | X | ? | ? | X | * * * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X |
| 12. | | Registration Taxes | | X | | X | X | | X | X * X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 13. | | User Fees | | X | | | X | | | X * * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X |
| 14. | Infrastructure | Indirect Subsidies | | | | | | | | * * * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X |
| 15. | | Regulated Rates | | X | * | * | X | | X | * * * | | X | X | * | X | X | X | X | X | X | X | X | X | X | * | X |
| 16. | Service | Subsidies | | X | X | X | | X | X | * * * | X | X | X | X | X | X | | X | * | * | X | | | X | * | * | X |
| 17. | | Statutory Rates | | X | X | X | X | X | X | X X X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 18. | Vehicle Size & Weight | Design/Standards | | X | X | X | ? | ? | ? | ? ? ? | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 19. | Routing | Design/Standards | | ? | | | ? | | | ? * * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | ? | | | ? | | | ? * * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 21. | Flow Quality | Design/Standards | | ? | | | ? | | | ? * * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 22. | Vehicle Size & Weight | Regulations | | X | X | X | X | | | X * * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 23. | Vehicle Performance | Regulations | | X | X | X | X | ? | X | X X X | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 24. Vehicles | Fuel Type & Quality | Various | | ? | ? | X | ? | ? | X | ? ? ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 25. | Fuel Economy | Guidelines | | | X | X | X | X | X | X X X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 26. | Vehicle Safety | Regulations/Standards | | ? | ? | X | ? | ? | X | ? ? X | | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 27. | Noise & Emissions | Regulations/Standards | | ? | ? | X | ? | ? | X | ? ? X | | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | X | | | X | * * * | ? | X | X | ? | X | X | X | X | X | X | X | X | ? | X | X | ? | X | X |
| 29. | Research & Development | Programs | | ? | ? | X | ? | ? | X | * * * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X |
| 30. | Routing | Regulations/By-Laws | | X | X | X | X | | | X X X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | * * * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | * * * | | X | X | * | X | X | ? | X | X | * | X | X | X | X | X | X | X |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | * * * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 34. | Loads | Regulations | | ? | ? | ? | ? | ? | ? | ? ? ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 35. | Service | Economic (Direct) Regulation | | X | * | * | X | | | * * * | | X | X | * | X | X | ? | X | X | * | X | X | ? | X | X | * | X | X |

- "X" no impact either because a level of government has no jurisdiction or because no issues have been identified;

- "?" possibly some impact, but no evidence has been found to suggest how significant the impact is; and,

- "*" possibly some impact, but the amount of fuel affected is too small to be considered significant.

To make it easier to follow the discussion in the text, Table 8.2 is repeated on the left-hand side of the following pages.

The "X's" shown on Table 8.2 are largely straight-forward: in any case, their placement on the matrix follows the discussion in the preceding Chapters. For example, considering the columns of the matrix, local government policies are shown to be of no concern to the air, marine, and rail components. In effect, these components of the transportation system do not fall under local government jurisdiction (ignoring some minor exceptions and some instances of local governments having a consultative role with the senior levels of government). As another example, the "special sales tax exemption" row of the matrix (row 5) is shown with "X's" for the air, marine, and rail components for all three levels of government. Although the federal and provincial governments have jurisdiction and various special exemptions, there are no issues as generally

# Table 8.2: POLICY AREAS WITH NO IMPACT

| POLICY CATEGORY | | | POLICY SOURCE ↓ | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X |
| 5. | Vehicle | Special Sales Tax Exemption | | | | X | | | X | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 6. | | Excise Tax | | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 7. | | Customs Duties | | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X |
| 8. | | Investment Tax Credit | | | | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X | | | X | * | * | X |
| 9. | | CCA | | | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X |
| 10. | | Special CCA | | ? | ? | X | ? | ? | X | * | * | * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X |
| 11. | | Grants/Assistance | | X | | X | X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 12. | | Registration Taxes | | X | | | X | | | X | * | * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X | X | X |
| 13. | | User Fees | | | | | | | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X | X | X |
| 14. | Infrastructure | Indirect Subsidies | | | | | | | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X | X | X |
| 15. | | Regulated Rates | | X | * | * | X | | X | * | * | * | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | * | X | X |
| 16. | Service | Subsidies | | X | X | X | | X | X | * | * | * | X | X | X | X | X | X | | X | X | * | * | X | | X | X | * | * | X |
| 17. | | Statutory Rates | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 18. | Vehicle Size & Weight | Design/Standards | | ? | | | ? | | | ? | * | * | X | X | X | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X |
| 19. | Routing | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X |
| 21. | Flow Quality | Design/Standards | | X | X | X | X | | | X | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 22. | Vehicle Size & Weight | Regulations | | X | X | X | X | ? | X | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 23. | Vehicle Performance | Regulations | | ? | ? | X | ? | ? | X | ? | ? | ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X |
| 24. Vehicles | Fuel Type & Quality | Various | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 25. | Fuel Economy | Guidelines | | | | | | | | ? | ? | X | | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X |
| 26. | Vehicle Safety | Regulations/Standards | | ? | ? | X | ? | ? | X | ? | ? | X | | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 27. | Noise & Emissions | Regulations/Standards | | | | X | | | X | * | * | * | ? | X | X | ? | X | X | X | X | X | X | X | X | ? | X | X | ? | X | X | X |
| 28. | Vehicle Maintenance | Regulations/Promotion | | ? | ? | X | ? | ? | X | * | * | * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X | X |
| 29. | Research & Development | Programs | | X | X | X | X | | | X | X | X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 30. | Routing | Regulations/By-Laws | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | * | * | * | | X | X | * | X | X | ? | X | X | * | X | X | X | X | X | X | X | X | X |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | X | * | * | X | | | * | * | * | | X | X | * | X | X | ? | X | X | * | X | X | ? | X | X | * | X | X | X |

all of the larger commercial vehicles are exempt from sales tax in any case.

Most of the "X's" shown are non-controversial in the sense that their positioning does not rely on judgement. Nevertheless, it should be pointed out that this process is not entirely "pure". For example, the "X's" shown for the air component under subsidy policies (row 16) could be debated. There are some subsidies for the air industry: the justification for ignoring these here is that, in comparison to the trucking, marine, and rail components (where no "X's" are shown), these are relatively minor.

The "?'s" rely somewhat more on judgement; although, again, their placement follows the discussion in the preceding Chapters. For example, most policies affecting infrastructure, that have not been shown with an "X", are shown with a "?". As suggested in Chapter 5, while infrastructure is clearly important in considering transportation energy efficiency, there is no real evidence that infrastructure is an important issue <u>if</u> increases in public expenditure are ruled out of scope. As another example, "fuel type & quality" (row 24) is shown with a series of "?'s" on the grounds that there is either some uncertainty as to what fuel quality does to efficiency, or what government policies can do about quality, or on the grounds that fuel type is more an issue of "energy-supply" or "substitution" than it is of efficiency.

## Table 8.2: POLICY AREAS WITH NO IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | | MEDIUM & HEAVY TRUCKS | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | | F | P | L | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | | 13.8% | | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | |
| 2. | | National Energy Program | | | | X | | | X | | | | X | | | X | | | X | | | X | | | X | | | X | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | X | | | X | | | | X | | | X | | | X | | | X | | | X | | | X | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | X | | | X | | | * | * | X | | X | | * | * | X | | X | | * | * | X | | * | * | X |
| 5. | Vehicle | Special Sales Tax Exemption | | | | X | | | X | | | * | * | X | | X | | * | * | X | | X | | * | * | X | | * | * | X |
| 6. | | Excise Tax | | | | X | | | X | | | * | * | X | | X | | * | * | X | | X | | * | * | X | | * | * | X |
| 7. | | Customs Duties | | ? | X | X | | X | X | | | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 8. | | Investment Tax Credit | | ? | X | X | | ? | X | X | | ? | X | X | ? | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 9. | | CCA | | | | X | | | | X | | * | * | X | | X | | * | * | X | | X | X | * | * | X | | ? | X | X |
| 10. | | Special CCA | | | X | X | | | X | X | | * | X | X | | X | X | * | X | X | | X | X | * | X | X | | | X | X |
| 11. | | Grants/Assistance | | | X | X | | | X | X | | * | X | X | | X | X | * | X | X | | X | X | * | X | X | | | X | X |
| 12. | | Registration Taxes | | ? | ? | X | | ? | ? | X | | * | * | * | ? | X | X | * | * | X | | ? | X | * | * | X | | ? | X | X |
| 13. | | User Fees | | X | | | | X | | | | X | * | * | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 14. | Infrastructure | Indirect Subsidies | | X | | | | | X | | | X | * | * | | X | X | * | X | X | | X | X | * | X | X | | X | X | X |
| 15. | | Regulated Rates | | | | | | | | | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | | X | X | X |
| 16. | Service | Subsidies | | X | * | * | | X | | X | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | | X | X | X |
| 17. | | Statutory Rates | | X | X | X | | | X | X | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | | * | X | X |
| 18. | Vehicle Size & Weight | Design/Standards | | X | X | X | | ? | ? | ? | | ? | ? | ? | X | X | X | * | X | X | | X | X | * | X | X | | X | X | X |
| 19. | Routing | Design/Standards | | ? | | | | ? | | | | ? | * | * | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | ? | | | | ? | | | | ? | * | * | | X | X | * | X | X | | X | X | X | X | X | X | X | X | X |
| 21. | Flow Quality | Design/Standards | | ? | | | | ? | | | | ? | * | * | | X | X | * | X | X | | X | X | X | X | X | X | X | X | X |
| 22. | Vehicle Size & Weight | Regulations | | X | X | X | | X | | | | X | * | * | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 23. | Vehicle Performance | Regulations | | X | X | X | | X | ? | X | | X | X | X | ? | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 24. Vehicles | Fuel Type & Quality | Various | | ? | ? | X | | ? | ? | X | | ? | ? | ? | ? | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 25. | Fuel Economy | Guidelines | | | X | X | | X | X | X | | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 26. | Vehicle Safety | Regulations/Standards | | ? | ? | X | | ? | ? | X | | ? | ? | X | | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 27. | Noise & Emissions | Regulations/Standards | | ? | ? | X | | ? | ? | X | | ? | ? | X | | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | X | | | | X | | * | * | * | ? | X | X | ? | X | X | | X | X | X | X | X | X | X | X | X |
| 29. | Research & Development | Programs | | ? | ? | X | | ? | ? | X | | * | * | * | ? | ? | X | * | * | X | | ? | X | * | * | X | | ? | X | X |
| 30. | Routing | Regulations/By-Laws | | X | X | X | | X | | | | X | X | X | | X | X | * | X | X | | X | X | X | X | X | X | X | X | X |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | | | * | * | * | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | * | * | * | | X | X | * | X | X | | ? | X | X | * | X | X | X | X | X |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | * | * | * | X | X | X | X | X | X | | X | X | X | X | X | X | X | X | X |
| 34. | Loads | Regulations | | ? | ? | ? | | ? | ? | ? | | ? | ? | ? | ? | X | X | ? | X | X | | ? | X | X | ? | X | X | ? | X | X |
| 35. | Service | Economic (Direct) Regulation | | X | * | * | | X | | | | * | * | * | | X | X | * | X | X | | ? | X | X | * | X | X | ? | X | X |

The placement of the "*'s" is primarily an issue of considering the columns on Table 8.2. That is, consider that the "transit & intercity bus" component consumes 1% of transportation fuel, that the "all other air" component consumes 1.6% (40% of which is by foreign carriers), that the "all other marine" component consumes 3.7% (80% by foreign carriers), and that the "passenger" component of rail consumes 0.4%. These components of the transportation system are too small for there to be any significant impact of government policies on transportation energy efficiency. Also included in this category (the "*'s") are two areas shown under "auto & light trucks": both of these areas involve taxi operations.

To summarize the "no" impact policy areas (using the row numbers on Table 8.2 as reference points): there is no evidence that excise taxes on large automobiles (line 6) or customs duties on vehicles or equipment (line 7) have any effect on energy efficiency; there is no evidence that there are any regulations affecting minimum vehicle performance capabilities (line 23) which are of consequence here; there is no evidence - although, admittedly, not enough is known about the subject - that there are any policies which could affect fuel type or fuel quality (line 24) which, in turn, would have an impact on energy efficiency; the evidence on the effect of policies affecting vehicle safety (line 26)

# Table 8.2: POLICY AREAS WITH NO IMPACT

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | | | TRANSIT | | | AIR | | | | | | MARINE | | | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | & INTER-CITY BUS | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | X | | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | X | | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X |
| 5. | Vehicle | Special Sales Tax Exemption | | | X | | | X | | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 6. | | Excise Tax | | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 7. | | Customs Duties | | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | X |
| 8. | | Investment Tax Credit | | | X | | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X | | X | | * | * | X |
| 9. | | CCA | | | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X |
| 10. | | Special CCA | | | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X | | X | X | * | X | X |
| 11. | | Grants/Assistance | | ? | ? | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X |
| 12. | | Registration Taxes | | X | | X | X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 13. | | User Fees | | X | | | X | | | X | * | * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X | X | X |
| 14. | Infrastructure | Indirect Subsidies | | | | | | | | * | * | * | | X | X | * | X | X | | X | X | * | X | X | X | X | X | X | X | X |
| 15. | | Regulated Rates | | X | * | * | X | | X | * | * | * | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | * | X | X |
| 16. | Service | Subsidies | | X | X | X | | X | X | * | * | * | X | X | X | X | X | X | | X | X | * | * | X | | X | X | * | * | X |
| 17. | | Statutory Rates | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | X | X | X | X |
| 18. | Vehicle Size & Weight | Design/Standards | | X | X | X | ? | ? | ? | ? | ? | ? | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X |
| 19. | Routing | Design/Standards | | ? | | | ? | | | ? | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X |
| 21. | Flow Quality | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X |
| 22. | Vehicle Size & Weight | Regulations | | X | X | X | X | | | X | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 23. | Vehicle Performance | Regulations | | X | X | X | X | ? | X | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 24. Vehicles | Fuel Type & Quality | Various | | ? | ? | X | ? | ? | X | ? | ? | ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 25. | Fuel Economy | Guidelines | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 26. | Vehicle Safety | Regulations/Standards | | ? | ? | X | ? | ? | X | ? | ? | X | | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 27. | Noise & Emissions | Regulations/Standards | | ? | ? | X | ? | ? | X | ? | ? | X | | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | X | | | X | * | * | * | ? | X | X | ? | X | X | X | X | X | X | X | X | ? | X | X | ? | X | X |
| 29. | Research & Development | Programs | | ? | ? | X | ? | ? | X | * | * | * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X | * | * | X |
| 30. | Routing | Regulations/By-Laws | | X | X | X | X | | | X | X | X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | * | * | * | | X | X | * | X | X | ? | X | X | * | X | X | X | X | X | X | X | X |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 34. | Loads | Regulations | | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 35. | Service | Economic (Direct) Regulation | | X | * | * | X | | | * | * | * | | X | X | * | X | X | ? | X | X | * | X | X | ? | X | X | * | X | X |

and vehicle noise and emissions (line 27) is conflicting (primarily in respect of automobiles) and the possibility of changing these policies (primarily safety) cannot be considered feasible; and, there is no evidence on the effect of any policies impacting loads (line 34) - as discussed in Chapter 7.

Additionally, there is insufficient evidence in two important policy areas - grants and assistance for transport operators or vehicle manufacturers (line 11), and all government research and development policies (line 29) - to know whether or not there has been any impact on energy efficiency. This grouping of these two policy areas is a difficult decision to make. Undoubtedly any government policy which assists in developing new technologies is important and there are known instances of where government agencies have been involved in various developments that have some consequence for transportation energy efficiency. Unfortunately what is not known is whether or not these developments would have occurred in the absence of government assistance, whether or not the development of new technologies guarantees their introduction to the transportation system, or whether or not the new technologies might have been available from non-Canadian sources. Without answers to these questions, these policy areas cannot be accorded any "higher" ranking here.

# Table 8.2: POLICY AREAS WITH NO IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | | | TRANSIT | AIR | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | & INTER-CITY BUS | LARGE DOMESTIC | | ALL OTHER AIR | | DOMESTIC CARRIERS | | ALL OTHER MARINE | | FREIGHT | | PASSENGER | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F P L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | 7.2% | | | 1.6% | 3.1% | | | 3.7% | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | X | | | X | | | X | | | X | | | X | | | X | | | X | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | X | | | X | X | | X | | | X | | | X | | | X | | | X | |
| 5. | | Special Sales Tax Exemption | | | | X | | | X | X | | X | | | X | | | X | | | X | | | X | |
| 6. | Vehicle | Excise Tax | | | | X | | | X | X | | X | | | X | | | X | | | X | | | X | |
| 7. | | Customs Duties | | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 8. | | Investment Tax Credit | | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 9. | | CCA | | | | X | | | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 10. | | Special CCA | | | X | X | | X | X | X | | X | | X | X | | | X | | | X | | | X | | |
| 11. | | Grants/Assistance | | | X | X | | X | X | X | X | X | | X | X | | | X | | | X | | | X | | |
| 12. | | Registration Taxes | | ? | ? | X | ? | ? | X | X | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| 13. | | User Fees | | X | | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 14. | Infrastructure | Indirect Subsidies | | X | | | X | | | X | X | X | | X | X | | | X | | | X | | | X | | |
| 15. | | Regulated Rates | | | | | | | | X | X | X | | X | X | | | X | | | X | | | X | | |
| 16. | Service | Subsidies | | X | * | * | X | | X | X | X | X | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 17. | | Statutory Rates | | X | X | X | | X | X | X | X | X | | X | X | | | X | | | X | | | X | | |
| 18. | | Design/Standards | | X | X | X | ? | ? | ? | ? | ? | ? | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 19. | Vehicle Size & Weight | Design/Standards | | ? | | | ? | | | ? | * | * | X | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 20. Infrastructure | Routing | Design/Standards | | ? | | | ? | | | ? | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 21. | Veh.Speed & Performance | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 22. | Flow Quality | Design/Standards | | ? | | | ? | | | ? | * | * | | X | X | X | ? | X | X | ? | X | X | X | X | X | X | X |
| 23. | Vehicle Size & Weight | Regulations | | X | X | X | X | | | X | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 24. Vehicles | Vehicle Performance | Regulations | | X | X | X | X | ? | X | X | X | X | ? | X | X | X | ? | X | X | X | X | X | X | X | X | X | X |
| 25. | Fuel Type & Quality | Various | | ? | ? | X | ? | ? | X | ? | ? | ? | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X |
| 26. | Fuel Economy | Guidelines | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | ? | X | X | ? | X | X | X | X |
| 27. | Vehicle Safety | Regulations/Standards | | ? | ? | X | ? | ? | X | ? | ? | X | | X | X | ? | X | X | ? | X | X | X | X | X | X | X | X |
| 28. | Noise & Emissions | Regulations/Standards | | ? | ? | X | ? | ? | X | ? | ? | X | | X | X | ? | X | X | ? | X | X | ? | X | X | X | X | X |
| 29. | Vehicle Maintenance | Regulations/Promotion | | | | X | | | X | * | * | * | ? | X | X | ? | X | X | X | X | X | X | X | X | X | X | X |
| 30. | Research & Development | Programs | | ? | ? | X | ? | ? | X | * | * | * | ? | ? | X | * | * | X | ? | ? | X | * | * | X | ? | ? | X |
| 31. | Routing | Regulations/By-Laws | | X | X | X | X | | | X | X | X | | X | X | * | X | X | X | X | X | X | X | X | X | X | X |
| 32. Operations | Speed | Regulations/By-Laws/Enforcement | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 33. | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | * | * | * | | X | X | * | X | X | ? | X | X | X | X | X | X | X | X |
| 34. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | * | * | * | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 35. | Loads | Regulations | | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | X | X | ? | X | X | ? | X | X | ? | X | X | ? | X | X |
| | Service | Economic (Direct) Regulation | | X | * | * | X | | | * | * | * | | X | X | * | X | X | ? | X | X | * | X | X | ? | X | X |

Table 8.2 may also be considered by looking at the columns (rather than the rows). With one exception (the NEP policies governing fuel prices), four columns have been relegated to this "no" impact category: "transit & inter-city bus", "all other air", "all other marine", and "rail passenger". Given the importance of these components in other policy considerations, this may be difficult to accept. However, if the "foreign" element is removed, the balance of these four columns only accounts for 3.0% of total transportation fuel consumption.

Still considering the columns, all policy areas affecting infrastructure, vehicles, and operations for the remaining marine and rail components have been included in this "no" impact category.

## 8.4 Policies With Little Impact

Grouping some of the areas on the matrix together, there are five policy areas with little impact on transportation energy efficiency. In all cases, "little impact" has to be understood as either an actual positive or negative impact given the existing policies or a potential positive or negative impact given some change to existing policies. The criteria for including a policy in this group is that the impact - if it actually exists - would account for no

## Table 8.3: POLICY AREAS WITH LITTLE IMPACT

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | L | L | L | L | L | L | | | | L | L | | | | | L | L | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | | L | L | | | | | | | | | | | | | | | | | | | | |

more than 1% of transportation fuel consumption. This 1% cut-off is arbitrary and is not based on any documented "hard" evidence.

These five policy areas are shown on Table 8.3 with the symbol "L". For clarity, Table 8.3 is a copy of the previous Table 8.2 with all "no" impact areas shaded. Again, the Table is repeated on the left-hand side of the following pages in order to make it easier to follow the discussion in the text.

First, as discussed in Chapter 4, there is a series of measures which affect the price of transportation services: rate regulation, indirect subsidies (that is, the "under-recovery" of infrastructure costs), and direct subsidies (lines 14, 15, and 16). These may affect the relative demand for transportation service - either the absolute amount (such as, say, in the Atlantic provinces) or the amount for one component in comparison to another. At a general level, these "distorted" demands may affect the efficiency - in the sense of overall resource allocation - of the transportation system. But, given these "distorted" demands, it would only be in cases where there was some impact such as "congestion" or "flow quality" where there could be a measurable change in the amount of energy used per unit of transportation output.

## Table 8.3: POLICY AREAS WITH LITTLE IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | | | | | | | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | L | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | | L | L | | | L | | | | | | | | | | | | | | | | | |

Second, as discussed in Chapter 5, infrastructure policies - that is, how they are designed and not additions by themselves - are important in considering transportation energy efficiency (lines 18 through 21). Nevertheless, the current policies (standards) are rarely the limiting factor in achieving higher levels of energy efficiency. This group of policies is included here in the "little" impact category, not because there has been any evidence that they actually are having an impact on energy efficiency, but rather because it has to be assumed there is always room for changing the emphasis of the building programs contained in annual capital budgets. While it is believed that this policy area is of primary concern to road vehicles in urban areas, on Table 8.3, the air component has also been included in recognition of the fact that some aspects of traffic control are related to infrastructure.

Third, all policies affecting aircraft or air operations are judged to have little impact on transportation energy efficiency (lines 22 through 35). This is based on: i) the modest amount of fuel involved (7.2% of total transportation fuel); ii) the recognition that most aspects of changing energy efficiency are under the control of the airlines themselves; and iii) the evidence presented in the recent study of the subject (see Chapter 7 for a description of the 1% - 5% "energy cost savings").

# Table 8.3: POLICY AREAS WITH LITTLE IMPACT

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | | | | | | | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | L | | | | | | L | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | | L | L | | | L | | | | | | | | | | | | | | | | | |

Fourth, the regulation (economic regulation) of for-hire operations is relegated to the "little" impact category on the basis of both the relatively small amounts of fuel involved and the lack of any firm evidence on the effects of regulation (line 35). Having said this, it must also be recognized that there are probably some specific or individual instances of where it could be shown that regulation had a negative impact on transportation energy efficiency. The difficulty, however, in giving too much weight to this possibility, is the incomplete knowledge of what happens to fuel efficiency in a totally unregulated situation.

Fifth, user fees for the air and marine industry (row 13) are included in the "little" impact category on the basis that, if these policies do affect energy efficiency, the amount of fuel affected is quite small. (In Chapter 4, it was recognized that there were some potential impacts arising from the structure of some of these user fees, but there was no evidence that these were large enough to have ever affected the choice of equipment used by a carrier.)

## 8.5 Policies With Some Impact

There are seven policy areas which either have some noticeable impact on transportation energy efficiency or where there

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | MARINE | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER |
| Element | Area | Specific Type | ↓ | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | | S | | | S | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | | S | S | | S | S | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | L | | | | | L | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | S | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | S | S | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | S | S | S | S | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | L | L | | | | L | | | | | | | | | | | | | | | | | |

could be a potential impact (that is, given a policy change). In all cases, the lack of hard evidence frustrates the attempt to say how much of an impact these policies could have. Nevertheless, the weight of the available evidence suggests that none of these seven areas could possibly affect more than 5% of total transportation fuel consumption.

These seven policy areas are shown with the symbol "S" on Table 8.4.

First, the structure of user fees for road vehicles (lines 12 and 13), while not currently having much of an impact, could be adjusted. It was recognized in Chapter 4, however, that the adjustments would probably have to be quite dramatic before any effects would be noticed. (The "necessary" adjustments might be very steeply graduated registration fees for automobiles - increasing with vehicle weight; and, very steeply graduated registration fees for trucks - decreasing per unit of potential payload.)

The second policy area included in this category is the statutory grain rates for the railways (line 17). Admittedly, this is included here with some hesitation as there are many other policy issues involved and as the current policies are in the process of being revised. However, the evidence from both the railways and the federal government's own studies

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | | | TRANSIT | AIR | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | & INTER-CITY BUS | LARGE DOMESTIC | | ALL OTHER AIR | | DOMESTIC CARRIERS | | ALL OTHER MARINE | | FREIGHT | | PASSENGER | |
| Element | Area | Specific Type | ↓ | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | 7.2% | | 1.6% | | 3.1% | | 3.7% | | 4.1% | | | 0.4% | |
| 2. | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | National Energy Program | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Taxes on fuel (sales,excise, etc.) | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | |
| 9. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | |
| 10. | | CCA | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Special CCA | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | |
| 13. | | Registration Taxes | | S | | | S | | | | | | | | | | | | | | | | |
| 14. | Infrastructure | User Fees | | S | S | | S | S | | | L | | | | L | | | | L | L | | | |
| 15. | | Indirect Subsidies | | L | L | L | L | L | L | | L | | | | L | | | | | | | | |
| 16. | Service | Regulated Rates | | | | | L | | | | L | | | | | | | | | | | | |
| 17. | | Subsidies | | | | | L | | | | | | | | L | L | | | L | L | | | |
| 18. | | Statutory Rates | | | | | | | | | | | | | | | | | S | | | | |
| 19. | Vehicle Size & Weight | Design/Standards | | | | | | | | | L | | | | | | | | | | | | |
| 20. Infrastructure | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | |
| 21. | Veh.Speed & Performance | Design/Standards | | L | L | | L | L | | | L | | | | | | | | | | | | |
| 22. | Flow Quality | Design/Standards | | L | L | | L | L | | | L | | | | | | | | | | | | |
| 23. | Vehicle Size & Weight | Regulations | | | | | S | S | | | | | | | | | | | | | | | |
| 24. Vehicles | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | |
| 26. | Fuel Economy | Guidelines | | S | | | | | | | | | | | | | | | | | | | |
| 27. | Vehicle Safety | Regulations/Standards | | | | | | | | | L | | | | | | | | | | | | |
| 28. | Noise & Emissions | Regulations/Standards | | | | | | | | | L | | | | | | | | | | | | |
| 29. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | |
| 30. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | |
| 31. | Routing | Regulations/By-Laws | | | | | S | S | | | L | | | | | | | | | | | | |
| 32. Operations | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | | | | | | | | | | | |
| 33. | Flow Quality | Regulations/By-Laws/Practices | | S | S | S | S | S | S | | L | | | | | | | | | | | | |
| 34. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | |
| 35. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | |
| | Service | Economic (Direct) Regulation | | | | | L | L | | | L | | | | | | | | | | | | |

(see Chapter 4) seems clear: the existence of these rates has affected the financial ability of the railways to invest in new equipment and infrastructure.

The third policy area included here is the provincial (and some local) regulations governing truck size and weights (line 22). This is an important issue for some trucking operations, and the general trend to liberalize these regulations over the past decade has been important. Nevertheless, based on the one known study with any empirical data on this issue, it has to be concluded that only a very small proportion of heavy trucks are now limited by the existing regulations or even the remaining interprovincial differences in these regulations.

The fourth policy area, routing, also involves medium and heavy trucks (line 30). While some reservations have to be maintained about the one study available on this issue, it nevertheless represents the only known empirical evidence. To repeat the point made in Chapter 7,there is a possibility that the existence of urban truck routes accounts for upwards of 1% of total transportation fuel consumption.

The fifth and sixth policy areas both involve road vehicles and the rules of practice governing the use of roads: speed

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | | | RAIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER | | |
| Element | Area | Specific Type | ↓ | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | S | | | S | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | | S | S | | S | S | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | L | | | | | L | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | S | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | | L | L | | L | L | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | | L | L | | L | L | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | S | S | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | S | S | S | S | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | L | L | | | | L | | | | | | | | | | | | | | | | | |

regulations (line 31) and traffic system management (TSM) (line 32). (Although the federal government is included within these policy areas, the number of federal roads are relatively minor.) For both of these areas, there exist numerous studies suggesting both the importance of the subject in considering transportation energy efficiency and the way improvements might be made (see Chapter 7). The thrust of these suggestions are accepted here. However, with very little quantifiable data on the existing situation (speeds, flow quality) and even less evidence on the feasibility of altering existing rules or procedures, some caution must be exercised in making any conclusions about the potential impact of these policies. In particular, the available evidence suggests that driver motivation or driver skill (and in all likelihood, energy prices which affect this motivation or skill) might be far more important than the actual rules or procedures governing road use. (There is no point in having TSM policies which allow optimal flow quality if drivers persist in their "jack-rabbit" habits!)

Whatever the case, the weight of available evidence suggests that these two policy areas have to be included in at least this third group of policies; there will be others who can defend their inclusion in the next group of policies.

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE ↓ | ROAD | | | | TRANSIT & INTER-CITY BUS | | AIR | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | LARGE DOMESTIC | | ALL OTHER AIR | | DOMESTIC CARRIERS | | ALL OTHER MARINE | | FREIGHT | | PASSENGER | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | |
| 2. | Fuel | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | Vehicle | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | S | | | S | | | | | | L | | | | | | L | | | | | | | | | | |
| 12. | | Registration Taxes | | S | S | | S | S | | | | | L | | | | | | L | | | | | | | | | | |
| 13. | Infrastructure | User Fees | | L | L | L | L | L | L | | | | L | | | | | | | | | | | | L | L | | | | |
| 14. | | Indirect Subsidies | | | | | | L | | | | | | | | | | | L | L | | | | | S | | | | |
| 15. | | Regulated Rates | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | | | | | | | L | | | | | | | | | | | | | | | | |
| 17. | | Statutory Rates | | | | | L | L | | L | L | | | | | | | | | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | L | L | | L | L | | L | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | | | | L | L | | L | L | | L | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | | | | | | | S | S | | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | S | | | | | | | | | L | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | L | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | L | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | S | S | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | S | S | S | S | S | S | S | S | | L | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | L | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | L | L | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | | | | | | | | | | | | | | | | | | | | | | |

The seventh policy that may have some impact on transportation energy efficiency is the federal government's guidelines for new car fuel economy (line 25). As discussed in Chapter 6, the debate over the actual impact of this policy has not been resolved. However, in recognition that part of the effect of this policy has been to provide the consumer with more information on fuel economy of different automobiles, and in recognition that this policy could be changed (in effect, strengthened), it has been allocated to the "some" impact category.

## 8.6 Policies With The Greatest Impact

Grouping the remaining areas of the matrix into four areas, there are four policy areas with the greatest impact for affecting transportation energy efficiency: i) federal and provincial policies affecting fuel prices (lines 2 and 3); ii) federal and provincial policies affecting vehicle and equipment prices (lines 4,5,8,9, and 10); iii) federal and provincial policies affecting vehicle maintenance (line 28); and iv) policies of all three levels of government affecting operator proficiency (line 33). Although hard evidence is lacking, in all four of these areas there is an actual or a potential impact of greater than 5% of total transportation fuel consumption.

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | TRANSIT & INTER-CITY BUS | AIR | | MARINE | | RAIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | Area | Specific Type | | AUTO & LIGHT TRUCKS | MEDIUM & HEAVY TRUCKS | | LARGE DOMESTIC | ALL OTHER AIR | DOMESTIC CARRIERS | ALL OTHER MARINE | FREIGHT | PASSENGER |
| | | | | F P L | F P L | F P L | F P L | F P L | F P L | F P L | F P L | F P L |
| 1. Percent Fuel Consumption | | | | 65.2% | 13.8% | 1.0% | 7.2% | 1.6% | 3.1% | 3.7% | 4.1% | 0.4% |
| 2. | | National Energy Program | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | |
| 12. | | Registration Taxes | | S | S | | | | | | | |
| 13. | | User Fees | | S S | S S | | L | | L | | | |
| 14. | Infrastructure | Indirect Subsidies | | L L L | L L L | | L | | L | | | |
| 15. | | Regulated Rates | | | L | | L | | | | L L | |
| 16. | Service | Subsidies | | | L | | | | L L | | S | |
| 17. | | Statutory Rates | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | L | | | | | |
| 19. | Routing | Design/Standards | | L L | L L | | | | | | | |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | L L | L L | | L | | | | | |
| 21. | Flow Quality | Design/Standards | | L L | L L | | L | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | S S | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | L | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | L | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | S S | | L | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S S S | S S S | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | S S S | S S S | | L | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | L L | | L | | | | | |

The first policy area (fuel prices), as discussed in Chapter 2, has been prejudged. That is, even prior to describing policies in Chapters 4 through 7, it was recognized that energy prices - hence, policies affecting energy prices - play a pervasive role in controlling the energy efficiency of the transportation system. This point, and the designation of this policy area to the "greatest" impact category, are beyond debate. Consider the available evidence:

- no policy area touches so many components of the transportation system at all times, in all circumstances.

- all components of the transportation system have a large incentive to react to energy price changes in the sense that fuel costs comprise a significant proportion of total running costs.

- the more recent evidence on the long term price elasticity of demand for fuel is high (see Chapter 2). While the general measures of price elasticity are not sufficient evidence to conclude that transport operators will adopt more energy-efficient technologies or procedures, they are certainly good evidence that this may be one of the responses.

- there have been several studies which have taken the question of the consumers' response to higher energy prices several steps beyond the simple measure of price elasticities. One of these studies concluded that about one-half (or a little less) of the long run

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE | ROAD | | TRANSIT & INTER-CITY BUS | AIR | | MARINE | | RAIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Element | Area | Specific Type | | AUTO & LIGHT TRUCKS | MEDIUM & HEAVY TRUCKS | | LARGE DOMESTIC | ALL OTHER AIR | DOMESTIC CARRIERS | ALL OTHER MARINE | FREIGHT | PASSENGER |
| | | | | F P L | F P L | F P L | F P L | F P L | F P L | F P L | F P L | F P L |
| 1. Percent Fuel Consumption | | | | 65.2% | 13.8% | 1.0% | 7.2% | 1.6% | 3.1% | 3.7% | 4.1% | 0.4% |
| 2. | | | | | | | | | | | | |
| 3. | Fuel | National Energy Program | | | | | | | | | | |
| 4. Price | | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | |
| 5. | Vehicle | Sales Taxes (incl. Exemptions) | | | | | | | | | | |
| 6. | | Special Sales Tax Exemption | | | | | | | | | | |
| 7. | | Excise Tax | | | | | | | | | | |
| 8. | | Customs Duties | | | | | | | | | | |
| 9. | | Investment Tax Credit | | | | | | | | | | |
| 10. | | CCA | | | | | | | | | | |
| 11. | | Special CCA | | | | | | | | | | |
| 12. | | Grants/Assistance | | | | | | | | | | |
| 13. | | Registration Taxes | | S | S | | | | | | | |
| 14. | Infrastructure | User Fees | | S S | S S | | L | | L | | | |
| 15. | | Indirect Subsidies | | L L L | L L L | | L | | L | | | |
| 16. | Service | Regulated Rates | | | L | | L | | | | L L | |
| 17. | | Subsidies | | | L | | | | L L | | S | |
| 18. | Vehicle Size & Weight | Statutory Rates | | | | | | | | | | |
| 19. | Routing | Design/Standards | | | | | L | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L L | L L | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L L | L L | | L | | | | | |
| 22. | Vehicle Size & Weight | Design/Standards | | L L | L L | | L | | | | | |
| 23. | Vehicle Performance | Regulations | | | S S | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Regulations | | | | | | | | | | |
| 25. | Fuel Economy | Various | | | | | | | | | | |
| 26. | Vehicle Safety | Guidelines | | S | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | L | | | | | |
| 28. | Vehicle Maintenance | Regulations/Standards | | | | | L | | | | | |
| 29. | Research & Development | Regulations/Promotion | | | | | | | | | | |
| 30. | Routing | Programs | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws | | | S S | | L | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Enforcement | | S S S | S S S | | | | | | | |
| 33. | Operator Proficiency | Regulations/By-Laws/Practices | | S S S | S S S | | L | | | | | |
| 34. | Loads | Regulations/Programs/Promotion | | | | | | | | | | |
| 35. | Service | Regulations | | | | | | | | | | |
| | | Economic (Direct) Regulation | | | L L | | L | | | | | |

price elasticity of demand for gasoline was reflected in a shift to more economical cars.[1] Another study, by examining the relationship between fuel prices and the market for energy-efficient cars, concluded that consumers were quite rational. (That is, higher energy prices do result in attempts at increasing energy efficiency.)[2]

- the evidence presented in Chapter 6 on the commercial sector's past (and projected future) improvements in terms of energy efficiency have to be seen in part as a response to increasing energy prices.

The second policy area is those measures affecting vehicle and equipment prices (lines 4, 5, 8, 9, and 10). (In the case of the railways, this would include infrastructure.) As discussed in Chapter 4, there are various policies - mostly at the federal level - which have some potential for affecting transportation energy efficiency through the encouragement to buy new vehicles (which are generally more efficient than old vehicles) or more energy-efficient new vehicles (that is, as compared to less efficient new vehicles). The most important of these are the exemptions from the federal sales tax, the investment tax credits, and the capital cost allowances for the larger commercial vehicles. Regarding the last two of these items, there is a considerable body of literature which has examined the effectiveness of these types of measures in encouraging investment. Very little (if any) of this literature deals specifically with the issue of Canadian tax policies and the Canadian transportation system.[3]

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| Element | Area | Specific Type | Policy Source | ROAD: Auto & Light Trucks F | P | L | ROAD: Medium & Heavy Trucks F | P | L | TRANSIT & INTER-CITY BUS F | P | L | AIR: Large Domestic F | P | L | AIR: All Other Air F | P | L | MARINE: Domestic Carriers F | P | L | MARINE: All Other Marine F | P | L | RAIL: Freight F | P | L | RAIL: Passenger F | P | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | S | | | S | | | | | | L | | | | | | L | | | | | | | | | | | |
| 13. | Infrastructure | User Fees | | S | S | | S | S | | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | | | | | | | | | | | | |
| 15. | Service | Regulated Rates | | | | | | | | | | | | | | | | | | | | | | | L | L | | | | |
| 16. | | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | S | | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | | | | S | S | | | | | | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | S | S | | | | | L | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | L | L | | | | | L | | | | | | | | | | | | | | | | | |

In the absence of the necessary empirical evidence, it is assumed that: i) the current policies do provide some incentives for operators of the larger commercial vehicles for up-grading their vehicles and equipment with newer - and generally more energy efficient vehicles and equipment; ii) there are few policies which are specifically designed to provide incentives for the purchase of equipment or vehicle components that are designed primarily to make transportation systems more energy efficient; iii) incentives offered to the operators of larger commercial vehicles under current policies are not as high as the incentives offered to some other sectors (for example, petroleum exploration) or the purchase of various other "energy conservation" equipment (for example, anything from the wide group of items such as thermal insulation material included in the special sales tax exempt list of energy conservation equipment or the larger investment tax credits or capital cost allowances available to investors in certain non-transportation equipment); and iv) the current policies offering some incentive for the purchase of new vehicles and equipment are not generally extended to the small vehicle, non-commercial components of the transportation system.

There are exceptions to this last statement (for example, Alberta has no sales tax); however, given the importance of these smaller vehicles in terms of total transportation

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE → | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | | |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales, excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | S | | | S | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | S | S | | S | S | | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | S | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh. Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | S | S | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | S | S | | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | S | S | S | S | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | L | L | | | | | L | | | | | | | | | | | | | | | | | |

fuel consumption and given the rapid technological changes available in some new automobiles and light trucks, it would appear that there is some potential for increasing the rate at which new vehicles replace old ones with some consequent significant effects on average energy efficiency.

To put this last issue - that is, the non-availability or limited availability of incentives for the smaller vehicles - in perspective, consider that as of 1980 only 13% of total automobile kilometres were accounted for by new (1980) cars.[4] These newer cars were considerably more fuel efficient - possibly in the range of 15% - than the average car in the total automobile fleet. While it would be clearly impossible to devise vehicle pricing policies (sales tax exemptions, grants registration fees, faster "write-offs" for automobiles used in commerce, etc.) which would instantaneously result in all old cars being replaced by new ones, it is obvious that even a small move in this direction would have important consequences. Even a 7% improvement in average automobile fuel efficiency (not including light trucks) would represent a saving of over 3% of total transportation fuel.

The third policy area to be included in this "greatest" impact category relates to vehicle maintenance policies (line 28), or, more particularly, the absence of any

## Table 8.4: POLICY AREAS WITH SOME IMPACT

| POLICY CATEGORY | | | POLICY SOURCE ↓ | ROAD | | | | | | TRANSIT & INTER-CITY BUS | | | AIR | | | | | | MARINE | | | | RAIL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | AUTO & LIGHT TRUCKS | | | MEDIUM & HEAVY TRUCKS | | | | | | LARGE DOMESTIC | | | ALL OTHER AIR | | | DOMESTIC CARRIERS | | | ALL OTHER MARINE | | | FREIGHT | | | PASSENGER |
| Element | Area | Specific Type | | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L | F | P | L |
| 1. Percent Fuel Consumption | | | | 65.2% | | | 13.8% | | | 1.0% | | | 7.2% | | | 1.6% | | | 3.1% | | | 3.7% | | | 4.1% | | | 0.4% | | |
| 2. | | National Energy Program | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. | Fuel | Taxes on fuel (sales,excise, etc.) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Price | | Sales Taxes (incl. Exemptions) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. | Vehicle | Special Sales Tax Exemption | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. | | Excise Tax | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. | | Customs Duties | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8. | | Investment Tax Credit | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. | | CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. | | Special CCA | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11. | | Grants/Assistance | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12. | | Registration Taxes | | S | | | S | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | | User Fees | | S | S | | S | S | | | | | L | | | | | | L | | | | | | | | | | | |
| 14. | Infrastructure | Indirect Subsidies | | L | L | L | L | L | L | | | | L | | | | | | L | | | | | | | | | | | |
| 15. | | Regulated Rates | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 16. | Service | Subsidies | | | | | L | | | | | | | | | | | | L | L | | | | | L | L | | | | |
| 17. | | Statutory Rates | | | | | | | | | | | | | | | | | | | | | | | S | | | | | |
| 18. | Vehicle Size & Weight | Design/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 19. | Routing | Design/Standards | | L | L | | L | L | | | | | | | | | | | | | | | | | | | | | | |
| 20. Infrastructure | Veh.Speed & Performance | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 21. | Flow Quality | Design/Standards | | L | L | | L | L | | | | | L | | | | | | | | | | | | | | | | | |
| 22. | Vehicle Size & Weight | Regulations | | | | | S | S | | | | | | | | | | | | | | | | | | | | | | |
| 23. | Vehicle Performance | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24. Vehicles | Fuel Type & Quality | Various | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25. | Fuel Economy | Guidelines | | S | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26. | Vehicle Safety | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 27. | Noise & Emissions | Regulations/Standards | | | | | | | | | | | L | | | | | | | | | | | | | | | | | |
| 28. | Vehicle Maintenance | Regulations/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29. | Research & Development | Programs | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 30. | Routing | Regulations/By-Laws | | | | | S | S | | | | | L | | | | | | | | | | | | | | | | | |
| 31. | Speed | Regulations/By-Laws/Enforcement | | S | S | S | S | S | S | | | | | | | | | | | | | | | | | | | | | |
| 32. Operations | Flow Quality | Regulations/By-Laws/Practices | | S | S | S | S | S | S | | | | L | | | | | | | | | | | | | | | | | |
| 33. | Operator Proficiency | Regulations/Programs/Promotion | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Loads | Regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 35. | Service | Economic (Direct) Regulation | | | | | | L | L | | | | L | | | | | | | | | | | | | | | | | |

significant "energy-efficiency" component to current policies (see Chapter 6). Admittedly, the inclusion of this policy area in this category is untested. What is known is that the state of maintenance of the average automobile and light truck has a negative impact on energy efficiency. While there is no consensus on the amount, various authors suggest anywhere from a very small amount up to over 11%. What is not known is whether any regulations, any vehicle testing program, or any promotional-type of policies could really be effective in improving maintenance practices. Therefore, the inclusion of this policy area here is primarily on the basis that <u>if</u> there were any potential for these policies to have an effect, the impact would be very large. For example, a 5% improvement in automobile and light truck fuel efficiency represents about three-quarters of the total fuel used by the railways.

The fourth and final policy area to be included in this "greatest" impact category is similar to the third. That is, the current policies affecting operator proficiency (line 33) are generally devoid of an "energy-efficiency" content (overlooking the various promotional policies now being run by the federal and some provincial governments); the issue of operator proficiency can have a very dramatic effect on fuel consumption ( much more of an effect than maintenance); but, when all is said and done, it has to

be admitted that it is not known how effective any government policies in this area would be. Therefore, the inclusion of this policy area here is for the same reason as the last one: the potential impacts are too large to ignore.

## 8.7 Conclusions

Table 8.5 contains a summary of all policy areas designated as having "no", "little", "some", and the "greatest" impact.

This study has sought to answer the question: "What is the extent to which government policies affect transportation energy efficiency?" This question has not been answered in any sense of "hard" numbers or quantifiable information. Rather, the answer has been made on the basis of impressions and observations derived from five factors: i) the "intent" - in many cases, the presumed intent of policies; ii) the "effort" exercised in implementing policies - where "effort" has to be understood in relative terms (that is, in comparison to effort expended in other policy areas); iii) the "changes", indeed the dramatic changes in energy efficiency which have occurred (in spite of, or because of the impact of policies); iv) the "peculiar role" of energy pricing policies; and v) the area where policies can have (and, may have had) the potentially greatest impact.

Table 8.5

ASSESSMENT OF POLICIES: SUMMARY

| | Policy Category | Policy Source | Transportation Component | Comments |
|---|---|---|---|---|
| **A.** | **Policies With No Impact** | | | |
| 1. | Price-Vehicles-Excise Tax | federal | automobiles | - insignificant |
| 2. | Price-Vehicles-Customs Duties | federal | all | - no known significant impacts |
| 3. | Vehicles-Performance-Regulations | federal, provincial | all | - no significant policies |
| 4. | Vehicles-Fuel Type & Quality - Various | federal | all | - evidence unclear; policies unknown |
| 5. | Vehicles-Safety-Regulations/ Standards | federal, provincial | all | - evidence conflicting; changes probably not feasible |
| 6. | Vehicles-Noise & Emissions - Regulations/Standards | federal, provincial | road | - evidence inconclusive or lacking |
| 7. | Operations-Loads-Regulations | federal, provincial | all | - few significant policies; no evidence |
| 8. | Prices-Vehicles-Grants/Assistance | all levels | all | - impossible to assess with current information |
| 9. | Vehicles-R & D - Various Programs | federal, provincial | all | |
| 10. | All Policies (except fuel price) | all levels | transit & inter-city bus, other air, other marine, rail passenger | - insignificant |
| 11. | Infrastructure, Vehicles & & Operations - All Policies | federal, provincial | marine, rail | - no known impacts |
| **B.** | **Policies With Little Impact** | | | |
| 12. | Price - Infrastructure & Service - Indirect Subsidies, Regulated Rates, Subsidies | all levels | all | - may affect the overall efficiency of the system; no specific evidence on the effect on energy efficiency |
| 13. | Infrastructure - All Policies | all levels | road, air | - rarely the limiting factor; major modifications (which are important) are out of scope |
| 14. | Vehicles & Operations - All Policies | federal | air | - small amount of fuel affected, small impact |
| 15. | Operations - Service - Economic (Direct) Regulation | all levels | all | - no clear evidence; small amount of fuel affected |
| 16. | Price - Infrastructure - User Fees | federal | air, marine | - no evidence |
| **C.** | **Policies With Some Impact** | | | |
| 17. | Prices - Vehicles & Infrastructure Registration Taxes, User Fees | provincial, local | road | - very large adjustments might have an impact |
| 18. | Prices-Service-Statutory Rates | federal | rail | - affects ability to invest in new equipment |
| 19. | Vehicles-Size & Weight - Regulations | primarily provincial | trucks | - past increases have been important |
| 20. | Operations-Routing-Regulations/ Bylaws | primarily local | trucks | - likely a significant impact; amount of fuel affected is moderate |
| 21. | Operations-Speed-Regulations/ Bylaws/Enforcement | Provincial, local (some federal) | road | - important issue; not clear the extent to which policies could be changed and have much effect |
| 22. | Operations-Flow Quality-Regulations/Bylaws/Practices | provincial, local (some federal) | primarily road vehicles in urban areas | - important issue; not clear the extent to which existing policies require changing |
| 23. | Vehicles-Fuel Economy Guidelines | federal | automobile | - debate not resolved; may have some impact |
| **D.** | **Policies With The Greatest Impact** | | | |
| 24. | Prices-Fuel-NEP, Taxes on Fuel | federal, provincial | all | - greatest impact; affects all components of transportation system in all situations |
| 25. | Prices-Vehicles-Sales Taxes (& Exemptions), Tax Credits, CCA | federal, provincial | all | - current policies have some positive impacts; "small" policy changes have potentially large impacts |
| 26. | Vehicles-Maintenance-Regulations/ Promotion | federal, provincial | primarily automobiles & light trucks | - current policies are neutral; there may be significant potential given some policy changes (this is largely untested) |
| 27. | Operations-Operator Proficiency Regulations/Programs/Promotion | federal, provincial | primarily automobiles & light trucks | - current policies are neutral; there may be significant potential given some policy changes |

The first observation concerns "intent": there have been some policy areas where there has been a specific intention to influence, in a positive way, transportation energy efficiency. This is not easy to prove in all cases as the intention of policy-makers is not always clear. In any case, some aspects of fuel pricing policies may be intended to influence energy efficiency; there is a series of federal and provincial "promotional" policies with the goal of improving efficiency; there are one or two tax exemption policies that belong in this category; the federal CAFE guidelines were clearly designed to impact efficiency; there have been several instances of provinces adjusting registration fees for road vehicles where there was some thought of influencing vehicle purchasing practices; there probably was some energy efficiency content to speed limit changes some years back; and so on. Nevertheless, there is a clear impression that the number of policies designed with the specific intention of affecting transportation energy efficiency are relatively few or relatively minor.

A good part of this first observation is based on the apparent "effort" that has been used to implement these policies; or, what amounts to the same thing, the lack of effort expended on other policies which could affect efficiency.

At this point, a very important digression has to be made. The observations (or impressions) on "intent", "effort", or

any other subject matter considered here are not criticisms. That is, the purpose of this study is not to criticize - or, conversely, compliment - those who are responsible for government policy: the purpose is only to answer the question of the impact of policies. If there is little "effort", there is presumably little impact; and, this statement can be made in a non-critical sense. A criticism could only be made if it were known that governments had some responsibility for doing something about transportation energy efficiency and if all other (possibly conflicting) policy goals were known.

To return to the second observation on "effort", the impression that there has been little effort is a relative impression gained from i) considering the effort put into other energy policy areas - think of "self-sufficiency", "substitution" or "conservation"; and ii) considering the magnitude of some of the fiscal measures (sales tax exemptions, capital cost allowances, tax credits) applicable to the transportation industry in comparison to other industries. On this second point, to repeat some observations made in Chapter 4, much higher incentives (CCA, investment tax credits) are available in other areas (for example, resource exploration); and, considering the importance of automobiles and light trucks, the general absence of sales tax exemptions or other fiscal incentives is certainly not an indication of a "major" effort.

The observations on "intent" and "effort" have to be severely tempered by a third observation. This is the inescapable observation that there have been dramatic improvements in transportation energy efficiency over the last few decades. Further, if the present knowledge about both known and possible future technology is any indication, there is every reason to believe these improvements will continue (see Chapter 6). These "improvements" cannot be categorically attributed to the impact of policies or to the impact of ordinary market forces. (For one thing, government policies are so instrumental in determining some of the key market prices that it is almost a "chicken and egg" problem trying to sort out what causes the changes.) Therefore, the question as to whether these changes have occurred because of or in spite of government policies cannot be given a definitive answer. However, there is a very pronounced impression - particularly from industry - that transportation energy efficiency has in the past and will in the future respond to market forces whether or not there are any government policies with either "intent" or "effort".

The most positive aspect of this third observation - on the actual changes which have occurred - is that it lends some weight to the possibility that, if there have been any policies with a negative impact on efficiency, the impacts must have been relatively minor. Admittedly, the

logic of this extended third observation is poor. That is, if energy efficiency had increased from 40 to 80 over the past two decades, it still could be that the effect of policies prevented the increase from being from 40 to 100. However, in the absence of any evidence that policies have had significant negative impacts, this third observation (poor logic included) will be used here as prima facie evidence that policies have probably not had a significant negative impact.

The fourth observation concerns the peculiar role of government energy pricing policies. Although it would be far easier to simply omit any comment on these policies from this final section of the report, it is hard to ignore these policies given that energy pricing policies play such a major role in government thinking and given that the previous section concluded that these policies have potentially the greatest impact on transportation energy efficiency.

What has been the effect of Canadian energy pricing policies? On the one hand, it would be very simple to conclude that the effect of policies which kept Canadian energy prices below world levels has been negative - at least, with respect to energy efficiency. But this seems to ignore two things: the rate of development of technology is more influenced by world prices than by Canadian prices (Canadian prices, of

course, may affect the rate at which this technology is adopted by Canadian operators); and, whatever past policies have been, Canadian prices are now very close to world prices. On this second point, considering both the most important transportation fuels (for automobiles and light trucks) and the effect of provincial tax policies, Canadian prices are (and have been) as high or higher than American prices. Perhaps the best that can be said is that Canadian energy pricing policies have possibly slowed the rate at which the transportation system has moved to higher levels of energy efficiency.

The fifth, and final observation concerns a re-examination of Tables 8.2 through to 8.4. Simple inspection of the fuel consumption percentages shown on the first row, and an appreciation for the process used to identify the impact of policies, suggests that the major area where government policies can impact transportation energy efficiency involves automobiles and light trucks in four policy areas: energy prices - the higher the price, the greater the impact; vehicle prices - various incentives to buy new or more efficient equipment; vehicle maintenance - although untested, a small improvement has potentially large impacts; and operator proficiency - again, somewhat untested (as to the extent to which policies can influence proficiency), but even moderate changes have potentially very large impacts.

To summarize, the precise extent to which government policies affect transportation energy efficiency is not known. In a negative sense, the number or importance of policies designed specifically to do something about energy efficiency appears to be small: repeated warnings have been made that this is a relative statement, and that subjects such as "conservation" (which may include efficiency) or "substitution" have to be distinguished from "efficiency". In a positive sense, there is no strong evidence to suggest that government policies have retarded the rate at which the transportation system has become more energy-efficient. Finally, it is clear that the most important area where government policies could (and do) affect efficiency involves the largest user of transportation fuel - automobiles and light trucks. Indeed, these users account for so much fuel use and the opportunities for increasing efficiency appear so large, that most other considerations - other policy areas, other transportation components - pale by comparison.

Notes to Chapter 8

1. D. J. Reynolds [87] who has examined this problem, references several Canadian studies which attempted to estimate the effect of gasoline prices on new car sales and on fleet utilization. Atlhough there are some problems in some of the methods used, the author concludes:

   " Thus the mileage price elasticity and new car sales price elasticity with respect to gasoline prices seem to be different (but consistent) measures of the same thing in the long run, so that it seems it can be said that the price elasticity of demand for gasoline will be approximately 0.7, of which approximately 0.4 will be reflected in reduced auto utilization, new car sales and fleet size and 0.3 in a new market shift to more economical cars, plus scrapping of least economical older cars."

   Reynolds concludes that a 5% annual increase in the real price of gasoline (at to-day's rate of inflation this would be about 14%-15% in current dollars) "would be virtually adequate to meet the self-sufficiency goal of stabilizing auto gasoline consumption at about 5 billion gallons annually . . . "

2. G. G. Daly and T. H. Mayor [37]. The authors write:

   " In the 1970's many policy-makers believed that consumers could not be relied upon to make rational judgments about energy consumption. Symptomatic of this view were the arguments often repeated that consumers would ignore the energy crisis, that they were inherently wasteful in the use of energy, that they were psychologically unable to give up large automobiles, and that such policies as mandatory efficiency standards for appliances and automobiles were the only way to prevent excessive dependence on imported fuel. The findings of this study clearly do not support these arguments. On the contrary, evidence from used car markets suggests that information possessed by consumers and utilized in their decision-making is comparable with that possessed by informed policy-makers."

3. This statement is based on the findings of a report by Thorne, Stevenson & Kellogg [94].

4. D. J. Reynolds [87], Table 1.

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## Appendix A: Industry, Government Contacts

1. Federal

1.1 Transport Canada - Strategic Planning - D. Oldford
- R. Hinchcliff
- Energy R. & D. Programs - W. Johnson
- Marine - D. Hirnshaw
- D. Chiasson
- Air - G. Ganapathy (Winnipeg)
- A. Doherty
- N. Staden
- Surface- J. Pringle
- B. Gardiner
- Dangerous Goods Directorate - M. Mathews
- W. Jancewicz
- Road & Motor Vehicle Traffic Safety Directorate
- J. Lawson
- E. Welburn
- TDC - various

1.2 E M & R - H. Mokhtar
- P. Reilley-Roe

1.3 CTC - E. Weinberg

1.4 IT & C - D. W. McEwan

2. Industry Contacts

2.1 Canadian Automobile Association - G. Cronyn, M. Godding

2.2 l'Association du Co-Yoiturage du Quebec - G. Forgues

2.3 Air Transport Association of Canada - G. Capern, G. Lindsay

2.4 C. P. Rail - P. Detmold

2.5 C. N. Rail - B. Syr

2.6 Canada Steamship Lines - E. DeRoche

2.7 Ontario Trucking Association - M. Strauch

2.8 Canadian Trucking Association - C. McLeod

2.9 Private Motor Truck Council of Canada - R. W. Neal

2.10 Dominion Marine Association - R. W. Timbrell

3. Provincial Contacts

3.1 Nfld. - L. White

3.2 N. B. - J. Ruggeri, G. Oldham

3.3 Quebec - various

3.4 Ontario - TEMP - R. Madill, L. Kidman
- various others

3.5 Manitoba - J. Wallace

3.6 Saskatchewan - M. Shaw

3.7 Alberta - M. Dolinsky

3.8 British Columbia - G. Clark

4. Other Contacts

4.1 RTAC - J. B. L. Robinson

## Appendix B: Technical Factors and Energy Efficiency

### B.1 Resistance

Transportation systems associated with large resistances, such as a truck in several inches of mud, require large expenditures of energy per distance travelled. Satellites, on the other hand, experience virtually no resistance once in orbit, and continue to perform a transport function with virtually no additional consumption of energy. There are a variety of categories of resistance to motion and, for each of these categories, there are a variety of factors affecting the total amount of resistance. However, because some of the types of resistance are relatively unimportant and because in some other cases there is not much opportunity for a government policy to have an impact on some types of resistance - or, the factors upon which the resistance depends - in this study, only the more important forms of resistance need be noted.

Rolling resistance, or "interface" resistance is one of the more important types of resistances experienced by all land and water-borne vehicles. Various equations have been developed for different sectors of the transportation system to measure this form of resistance, but for the purposes of this study it is not necessary to go into this level of detail. Rather, the important points to note about rolling resistance - more particularly, the important points to note in light of where government policies may have an impact are as follows:

i) with respect to automobiles or trucks or any vehicles moving over the roads, total rolling resistance increases with the weight of the vehicle (more about this in Section B.3), it increases or decreases on "hard" or "soft" surfaces, and it increases or decreases somewhat with the type and pressure of tires. (There are other factors affecting rolling resistance such as speed, ambient temperature, type of wheel, bearings, etc. that are not particularly important for the purpose of this study.)

ii) rolling or interface resistance experienced by ships is caused by a set of factors that are somewhat different than for vehicles with wheels; however, since there are no known government policies which have any appreciable effect on these factors, there is no need to elaborate on this here.

iii) trains experience the least amount of rolling resistance for a given weight of any of the land-based transportation modes: colloquially, this may be called the "steel-wheel-on-steel rail" phenomenon. As with automobiles and trucks, the total weight of a train is the most critical factor in determining the total amount of rolling resistance experienced. Some further aspects of this weight factor are considered in Section B.3. The only other observation to make at this point is that some aspects of the equipment used by the railways can decrease this form of resistance.

Aerodynamic drag is a second form of resistance experienced by all the segments of the transportation system being considered here. For the purpose of this study, the two most important factors affecting aerodynamic drag are the design of the vehicle (where "design" includes factors such as frontal area, "smoothness", etc.) and the speed at which

the vehicle operates. A complete discussion of "aerodynamics" can be quite complex: for example, it would have to include such things as a consideration of the altitudes flown by aircraft (air is less dense at higher altitudes and, hence, aerodynamic drag is less), the configeration of different types of railway cars in a train, the spacing between truck tractors and trailers, and so on. However, considering just those factors over which government policies have some effect, speed is probably the most important consideration in this study. In particular, it is useful to note that as speed doubles, aerodynamic drag quadruples.

A third type of resistance is known as "acceleration resistance". Generally, this is not as important as rolling resistance or aerodynamic drag for this study. However, there are several situations - most particularly with respect to road vehicles in urban situations (for example, "stop and go" driving situations) - where this form of resistance does become significant.

There are a variety of other types of resistance - such as "grade" resistance, coriollis loading, curve resistance, etc. - which are not considered to be important here. Finally, it can be noted that increasing the distance travelled over the shortest possible distance between two

points increases the total resistance (generally all types) to be overcome.

To summarize, the relationship between resistance and transportation energy efficiency is straightforward: the more resistance experienced, the more energy required, and the lower the "transport output/energy input" ratio. To illustrate this, the following figures show the relative importance of rolling resistance and aerodynamic drag for some typical automobiles.

First, consider two automobiles that only differ in respect to total weight, type of tires, and the condition of the pavement. The first automobile weighs 2,336 kilograms (including one passenger), uses bias ply-tires, and is driven over "poor" pavement(that is, rough or broken). Typically, such a car would require .0655 litres of gasoline per kilometre to overcome this resistance. The second automobile only weighs 1,610 kilograms (including one passenger), uses radial-ply tires, and is driven over "good" pavement (smooth). In this case, such a vehicle would require something like .0302 litres of gasoline per kilometre - that is, less than half as much as the first automobile.[1]

Second, to illustrate the effect of aerodynamic drag,

consider two automobiles indentical in all respects except for three factors. The first automobile has a front surface area 14% larger than the second, it is not as well designed aerodynamically as the second vehicle, and it is driven at 100 kilometres per hour as compared to 90 kilometres per hour for the second car. The first automobile typically would require .0879 litres of gasoline per kilometre to overcome the resistance, whereas the second would only require about 43% as much.[2]

While both of these illustrations require a few assumptions to be made with respect to operating conditions, they are fairly typical in terms of the results they show. Quite clearly, rolling resistance and aerodynamic drag are of vital importance in considering what factors determine energy efficiency.

## B.2 Mechanical Efficiency

Today, most transport systems utilized in Canada employ a heat engine to convert the thermal energy of a petroleum-derived fuel into mechanical energy capable of doing useful work. The popular engines include the Otto cycle for spark-ignition engines (using gasoline or propane), the Diesel cycle for diesel engines, and gas-turbine types of fan engines and jet engines for aircraft. Marine vessels can employ any of these types of power plants; plus nuclear

power and steam engines. Certain transport systems may utilize any of the above types of engines to produce electricity, or utilize electricity generated by other means, which in turn is transformed into the mechanical energy of the system.

In transforming one form of energy into another losses must occur. Such losses are nearly always greater than 50%. In addition to this transformation loss, pumping losses, frictional losses, heat losses, accessory losses and drive train losses, typically further reduce the amount of useful energy output. The ratio of useful work output available from any propulsion sytem as compared to energy input to the system is referred to as "mechanical efficiency" (for example, mechanical energy available at the interface between the driving wheels of a car and the road surface divided by the energy content of the fuel consumed). Typical values of maximum mechanical efficiency for various types of engines are:

| | |
|---|---|
| 2-stroke spark ignition engines | 14-18% |
| 4-stroke spark ignition engines | 16-28% |
| rotary piston engines | 22-27% |
| diesel engines | 23-33% |
| gas turbines | 22-35% |

These values are reduced somewhat by the time the mechanical energy is actually converted to useful work (for example, drive line losses, etc.).

The values of mechanical efficiency presented in the above figures are "maximums", and are associated with operating the engine at its maximum power output (a function of the product of speed and resistance). In many practical situations, engines used in transport are not fully loaded. That is, the power required from them is less than they are capable of producing. When this happens, the actual efficiency of the engine can fall substantially below maximum efficiency. This is a particularly significant factor affecting energy efficiency of automobiles in urban areas; to this effect, most automobiles are substantially over-powered relative to the resistances and speeds they experience in urban areas. Thus, automobiles in urban areas are often operated in a manner producing (say) 10% mechanical efficiency versus a maximum mechanical efficiency of (say) 20%.

To summarize, the higher the mechanical efficiency of a propulsion system - either the potential maximum or, given the operating circumstances, the actual mechanical efficiency - the more energy in a given quantity of fuel is actually used to produce useful work output. This obviously increases the transportation energy efficiency of the system.

It is not necessary to provide any illustrations to show the importance of mechanical efficiency; that is, a quick

reference back to Figure 2.1 in Chapter 2 shows that the effect of changing "ME" from 30% has immediate consequences on the transportation energy efficiency ratio. Nevertheless, one of the most dramatic instances of improved mechanical efficiencies might be noted simply to show some of the changes that have occurred within the transportation system. In 1953, Canadian railways operated 4,800 locomotives, most of which were steam using coal as the source of energy. These locomotives consumed 179.35 billion megajoules of energy. By 1978, there were only 4,057 locomotives, all diesel-electric, consuming 75.96 billion megajoules of energy but producing over twice as many tonne-kilometres of output! In other words, in twenty-five years the railways were using less than half as much energy to produce twice as much transport work. Assume "service" did not change (and it probably did), this is a five-fold increase in transportation energy efficiency. Most of this improvement came about through the switch from coal-burning locomotives with mechanical efficiencies of 4% to 5% to diesel-electric locomotives with mechanical efficiencies of about 30%.[3]

## B.3 Payload to Gross Weight Ratio

Resistance of motion depends on, among other things, the gross weight of a vehicle (tare weight, plus payload, plus fuel) and the vehicle's dimensions. While both

gross weight and a vehicle's dimensions are related to the payload-handling capabilities of a vehicle, the nature of the relationships is generally complex. In only rare cases is either the weight or volume-handling capabilities of a particular vehicle type directly related to gross weight or gross dimensions. Since transport energy efficiency is dependent on the amount of payload handled per unit of energy input, an understanding of the relationship between payload and total resistance for various types of vehicles and operations is of fundamental importance to a study of transportation energy efficiency.

This is an extremely complex subject; in fact for each type of vehicle employed by those components of the transportation system under consideration here, there is room for a separate report. Overlooking this complexity here and ignoring the dangers inherent in generalizations, there appear to be two key observations. First, considering a vehicle of a given size, it is apparent that the higher the ratio of payload to gross weight, the more useful transport work is performed per unit of energy consumed. Second, considering different-sized vehicles, there is clearly an increasing ability of larger vehicles to handle more payload with less energy consumed per unit of payload. (This second observation is related to the first in one sense: with most existing vehicles the payload to gross weight ratio increases with larger vehicles. It

is not known what the practical upper limits to this tendency are, nor, considering the entire thrust of the second observation, is it known if factors other than the ratio of payload to gross weight are at work making "large" vehicles more energy-efficient than "small" vehicles.) In any case, within the relevant range of vehicles considered in this study, there is a fundamental, and measurable, phenomenon that links these two observations: as the payload to gross weight ratio increases, whether in a vehicle of a given size or in larger and larger vehicles, the total amount of resistance experienced per unit of payload decreases.

In considering the effect of increasing payload to gross weight ratios, some care has to be taken. First, it is obvious that the mere potential for larger vehicles to achieve higher levels of energy efficiency does not mean that larger vehicles will actually achieve these higher levels. In fact, for some components of the transportation system, particularly automobiles, the real issue is smaller vehicles. The reason for this is that in many cases, for a given service level, payloads are fixed. Second, in cases where payloads are not fixed, some care has to be taken in making the claim that larger payloads always result in higher levels of transportation energy efficiency. This is particularly true for passenger transportation systems where higher payloads may decrease service levels. This is the classical "apples and oranges" problem discussed previously where the attempt to measure changes in efficiency are confounded by changes in the "service" component of the numerator.

With these cautionary notes, then, the following illustrations show the importance of payload to gross weight changes in the case of one component of the transportation system. Consider, first, a typical "small" automobile with four passengers in comparison to a typical "large" car with only one passenger. For the sake of the illustration, all other factors - such as mechanical efficiency, the aerodynamic designs, the type of tires, the speed - are held constant. The only difference between the two vehicles is that the larger car weighs 2,336 kilograms (including one passenger) and the smaller car weighs 1,814 kilograms (with four passengers). (The one factor which is assumed to be the same for the two vehicles - the frontal area makes the illustration somewhat unrealistic.) In terms of comparing the transportation energy efficiency of the two vehicles, assuming service levels are comparable, the following points are pertinent: i) there is over five times as much rolling resistance per passenger in the large car as there is in the small car with four passengers; ii) there is four times as much aerodynamic drag per passenger in the large car; and iii) the large car consumes 4.4 times as much energy per passenger-kilometre.[4]

Notes to Appendix B

1. The example used in the text is, of course, highly illustrative. It is based on work done for this study by P. B. Hertz at the University of Saskatchewan; the examples were developed using imperial measures. Assuming a total weight of 5,150 lbs., a coefficient of rolling resistance of .015 for bias ply tires, and a "road factor" of 0.2 to account for the "poor road (see Wilbur Smith & Associates [103 ]), total rolling resistance for the first automobile is:

$$(.015)\ (5{,}150)\ (1.2) = 92.7 \text{ lbs.}$$

For the second automobile with a total weight of 3,500 lbs., a coefficient of rolling resistance of .012, and a "road factor" of 0.0, total rolling resistance is:

$$(0.12)\ (3{,}550)\ (1.0) = 42.6 \text{ lbs.}$$

The fuel consumption required to overcome this resistance can be calculated from:

$$\text{mpg} = \frac{(\text{mechanical efficiency})\ (20{,}000)}{\text{resistance}}$$

where 20,000 is the approximate "mile-pounds" of energy available in a gallon of gasoline (i.e., roughly $10.8 \times 10^7$ ft. - lb. per gallon divided by 5,280 ft.). The first car would require about 0.0232 gallons per mile to overcome this resistance; the second car would require 0.0107. (Mechanical efficiencies of 20% are assumed in both cases.)

2. As in the previous note, the basis for the examples have been provided (in imperial measures) by P. B. Hertz. The aerodynamic resistance encountered by the first automobiles is:

$$(.5)(.0024)(.5)(25)(91^2) = 124.2 \text{ lbs.}$$

where the third expression shown (.5) is the wind mean averaged drag coefficient, the fourth (25) is the frontal area of the vehicle in sq. ft., and the last expression ($91^2$) is the square of the speed in feet per second. The aerodynamic drag encountered by the second automobile is:

$$(.5)(.0024)(.3)(22)(82^2) = 53.3 \text{ lbs.}$$

It will be noted that, in comparison to the first automobile, the wind mean averaged drag coefficient has been reduced to .3 (about the level some newer cars are now advertizing), the frontal area has been reduced to 22 sq. ft., and speed has been reduced to 82 ft. per second (90 km/hr.).

The fuel consumption required to overcome these levels of resistance, assuming mechanical efficiency of 20% in both cases and gasoline-powered engines, is .0311 and .0133 gallons per mile respectively.

3. R. S. Wallace & Associates Ltd. [ 80 ] was the source for the figures noted in the text.

4. The differences between the two automobiles are as follows:

| | #1 | #2 |
|---|---|---|
| - vehicle weight | 5,000 lbs. | 3,400 lbs. |
| - passengers | 1 | 4 |
| - passenger weight | 150 lbs. | 600 lbs. |
| - coefficient of rolling resistance | .015 | .015 |
| - frontal area | 25 sq.ft. | 25 sq.ft. |
| - speed | 100 km/hr. | 100 km/hr. |
| - drag coefficient | 0.5 | 0.5 |
| - mechanical efficiency | 20% | 20% |

Total rolling resistance plus aerodynamic resistance is:

#1 $(.015 \times 5{,}150) + (.5 \times .0024 \times .5 \times 25 \times 91^2) = 201.5$ lbs.

#2 $(.015 \times 4{,}000) + (.5 \times .0024 \times .5 \times 25 \times 81^2) = 184.2$ lbs.

The fuel consumption of the two vehicles is:

#1 $\frac{.20 \times 20{,}000}{201.5} = 19.9$ mpg (0.0504 gal./mile)

#2 $\frac{.20 \times 20{,}000}{184.2} = 21.7$ mpg (.0461 gal./mile)

POOR

QUALITY

ORIGINAL